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RADIOLOGICAL HEALTH DATA. VOLUME 2, NUMBERS 7-9, JULY-SEPTEMBER 1961

Public Health Service
Washington, D. C.

September 1961

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- Radioactivity
- Air
- Water
- Milk
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- Human

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RADIOLOGICAL HEALTH DATA

QUARTERLY REPORT JULY 1961

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SECTION I.—AIR

Radiation Surveillance Network

Division of Radiological Health, Public Health Service

The Public Health Service Radiation Surveillance Network was established in 1956 in cooperation with the Atomic Energy Commission to provide a means of promptly determining increases in levels of environmental radioactivity due to fallout from nuclear weapons tests. Although no nuclear tests have been conducted by the United States since 1958, the program has proved sufficiently valuable that it has been extended to a year-round basis. Currently, it consists of 45 stations at urban locations (see figure 1) operated by State and local health department personnel with 2 stations operated by Public Health Service personnel.

Measurements of gross beta radioactivity in air have been taken since they provide one of the earliest and most sensitive indications of increases of activity in the environment and thus act as an "alert" system. A direct evaluation of biological hazards is not possible from these data alone. Field measurements enable the operator to estimate the amount of beta activity of particulates in air at the station five hours after collection by comparison with a known source using a portable survey meter. The filters are then forwarded to the central laboratory of the Radiation Surveillance Network in Washington, D.C., for a more refined measurement using a thin window proportional counter. The stations located at Atlanta, Georgia, and Cincinnati, Ohio, conduct their own laboratory analyses.

Air samplers are in operation at the 45 stations on an average of 70 percent of the week. Air is drawn through a carbon-loaded cellulose dust filter using a high volume air sampler. The radioactive material in fallout adhering to small particles is retained on the filter. Some gaseous fission products are adsorbed by the carbon. The contribution by gaseous fission products has represented only a small part of the total beta activity in these samples. About 85 percent of the stations collect samples of precipitation which are sent to Washington, D.C. for analysis. Values are now below limits of detection by present instrumentation.

Tables 1 and 2 summarize the data for February 1961. *Radiological Health Data,* Vol. I, No. 4 graphically presented the monthly averages of beta activity in air from about 1956 through 1959. Figures 2 through 45 bring this presentation up-to-date through 1960. It is to be noted that the levels of fission product gross beta activity in air in the United States have generally decreased below the Network's lower limit of detectability.

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FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS

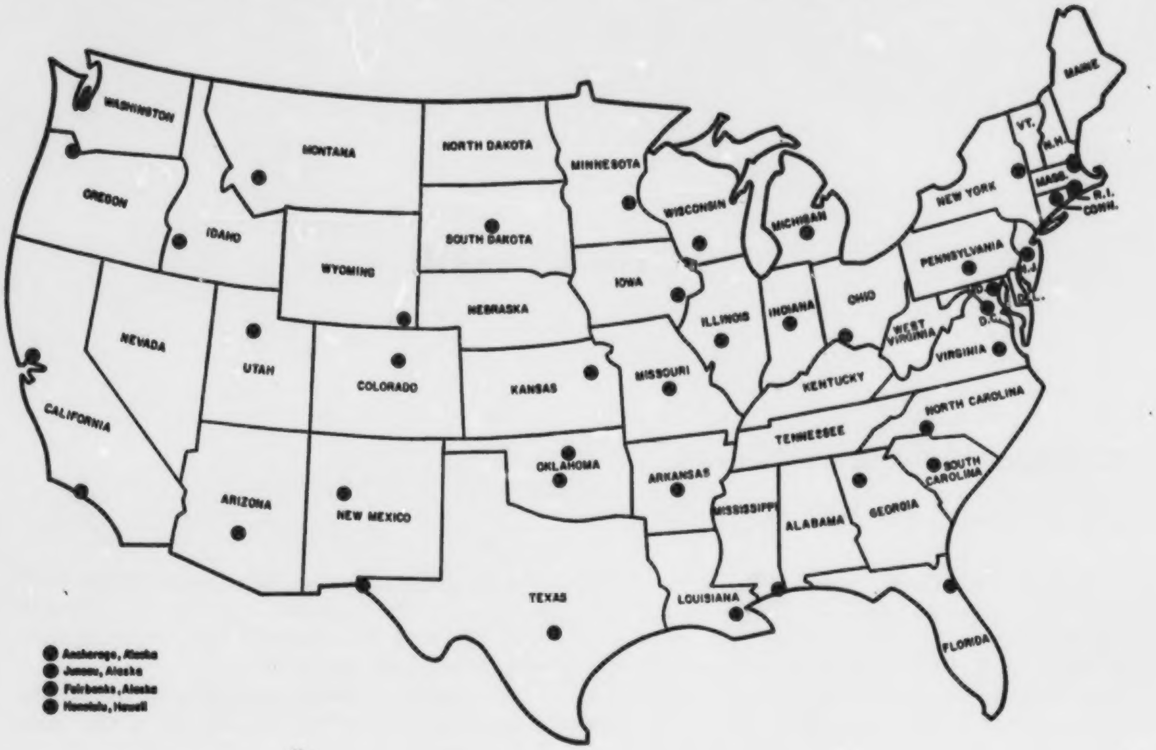

TABLE 1.—RADIOACTIVITY OF PARTICULATES IN AIR—GROSS BETA DETERMINATIONS

FEBRUARY 1961, Radiation surveillance Network, Public Health dervice

Station location	Number of samples	Maximum ($\mu\mu c/m^3$)	Minimum ($\mu\mu c/m^3$)	Weighted average ($\mu\mu c/m^3$)	Station location	Number of samples	Minimum ($\mu\mu c/m^3$)	Maximum ($\mu\mu c/m^3$)	Weighted average ($\mu\mu c/m^3$)
Anchorage, Alaska	19	0.11	<0.10	<0.10	Pascagoula, Miss	18	0.26	<0.10	<0.13
Fairbanks, Alaska	20	0.12	<0.10	<0.10	Jefferson City, Mo	17	<0.10	<0.10	<0.10
Juneau, Alaska	20	<0.10	<0.10	<0.10	Helena, Mont	17	0.12	<0.10	<0.10
Phoenix, Ariz	3	0.20	<0.10	<0.13	Trenton, N. J	0			
Little Rock, Ark	19	0.13	<0.10	<0.11	Sante Fe, N. M	16	0.18	<0.10	<0.12
Berkeley, Calif	18	<0.10	<0.10	<0.10	Albany, N. Y	28	<0.10	<0.10	<0.10
Los Angeles, Calif	17	0.25	<0.10	<0.13	Gastonia, N. C	19	0.16	<0.10	<0.11
Denver, Colo	18	0.15	<0.10	<0.11	Oklahoma City, Okla	18	0.15	<0.10	<0.10
Hartford, Conn	27	<0.10	<0.10	<0.10	Ponca City, Okla	26	0.70	<0.10	<0.12
District of Columbia	18	0.12	<0.10	<0.10	Portland, Ore	19	<0.10	<0.10	<0.10
Jacksonville, Fla	20	0.21	<0.10	<0.12	Harrisburg, Penn	18	<0.10	<0.10	<0.10
Atlanta, Ga	15	0.12	<0.10	<0.10	Providence, R. I	18	0.13	<0.10	<0.10
Honolulu, Hawaii	19	<0.10	<0.10	<0.10	Columbia, S. C	4	0.11	<0.10	<0.11
Boise, Idaho	8	0.12	<0.10	<0.10	Edgemont, S. Dak	(1)	(1)	(1)	(1)
Springfield, Ill	8	<0.10	<0.10	<0.10	Pierre, S. Dak	7	<0.10	<0.10	<0.10
Indianapolis, Ind	27	0.13	<0.10	<0.10	Austin, Tex	19	0.11	<0.10	<0.10
Iowa City, Iowa	20	0.22	<0.10	<0.10	El Paso, Tex	19	0.28	<0.10	<0.18
Topeka, Kan	20	0.14	<0.10	<0.10	Salt Lake City, Utah	28	0.15	<0.10	<0.10
New Orleans, La	4	0.13	<0.10	<0.11	Richmond, Va	19	0.12	<0.10	<0.10
Baltimore, Md	18	0.13	<0.10	<0.10	Seattle, Wash	15	<0.10	<0.10	<0.10
Lawrence, Mass	18	0.13	<0.10	<0.10	Madison, Wis	20	0.11	<0.10	<0.10
Lansing, Mich	28	0.10	<0.10	<0.10	Cheyenne, Wyo	8	<0.10	<0.10	<0.10
Minneapolis, Minn	8	<0.10	<0.10	<0.10					

[1] Inactivated

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BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Anchorage, Alaska

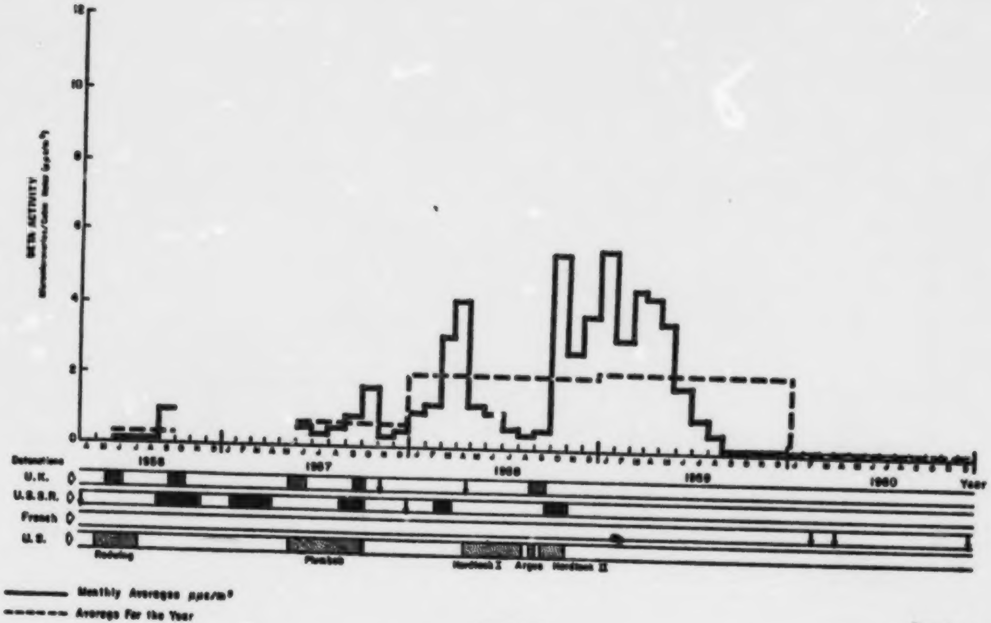

FIGURE 2

Single Shot

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Fairbanks, Alaska

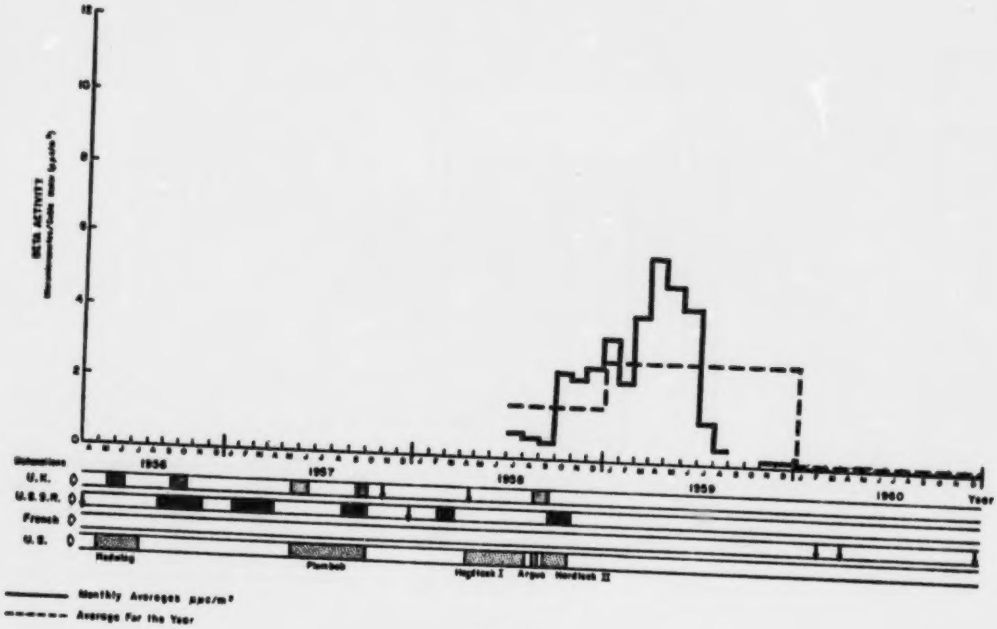

FIGURE 3

Single Shot

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BETA ACTIVITY OF AIR-BORNE PARTICULATES
RADIATION SURVEILLANCE NETWORK
Juneau, Alaska

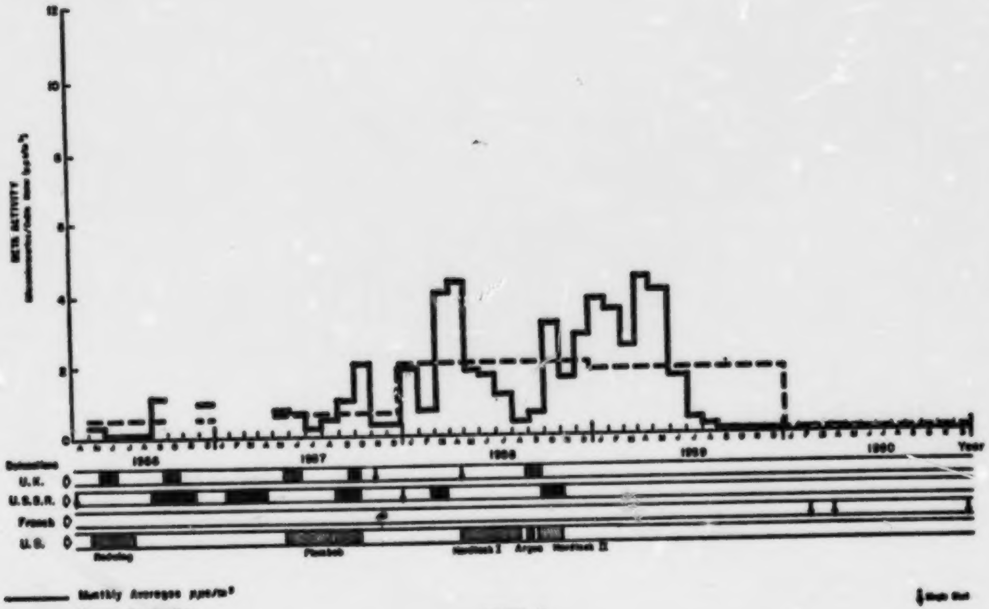

FIGURE 4

BETA ACTIVITY OF AIR-BORNE PARTICULATES
RADIATION SURVEILLANCE NETWORK
Phoenix, Arizona

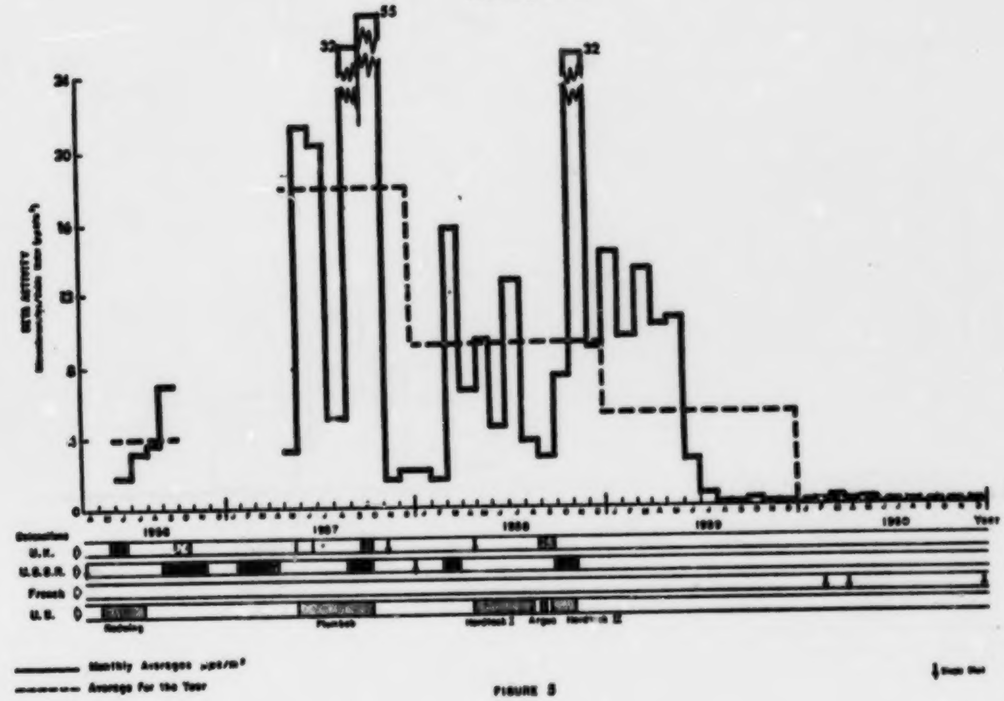

FIGURE 5

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BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Little Rock, Arkansas

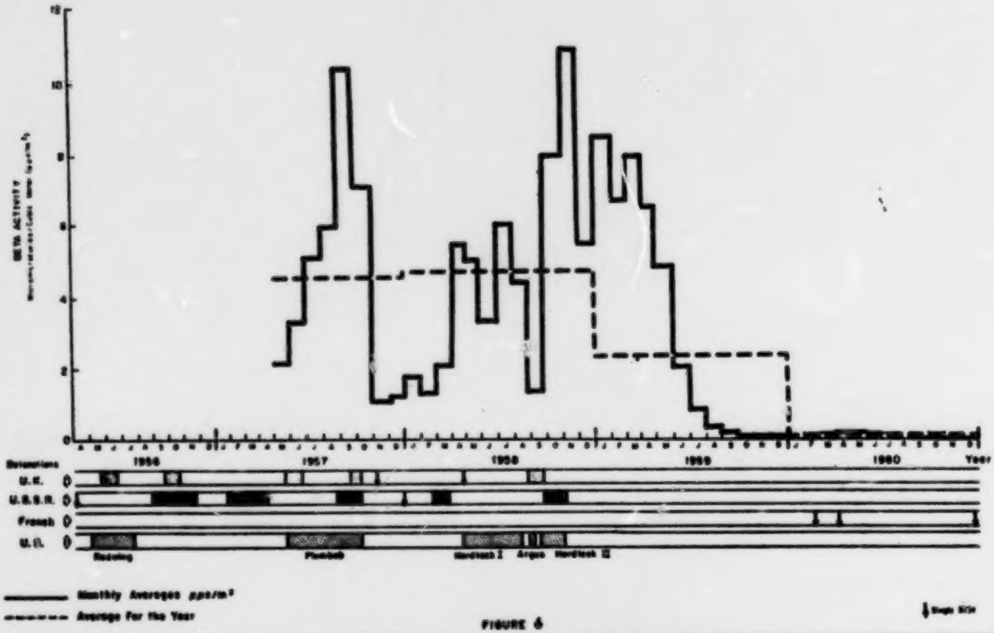

FIGURE 6

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Berkeley, California

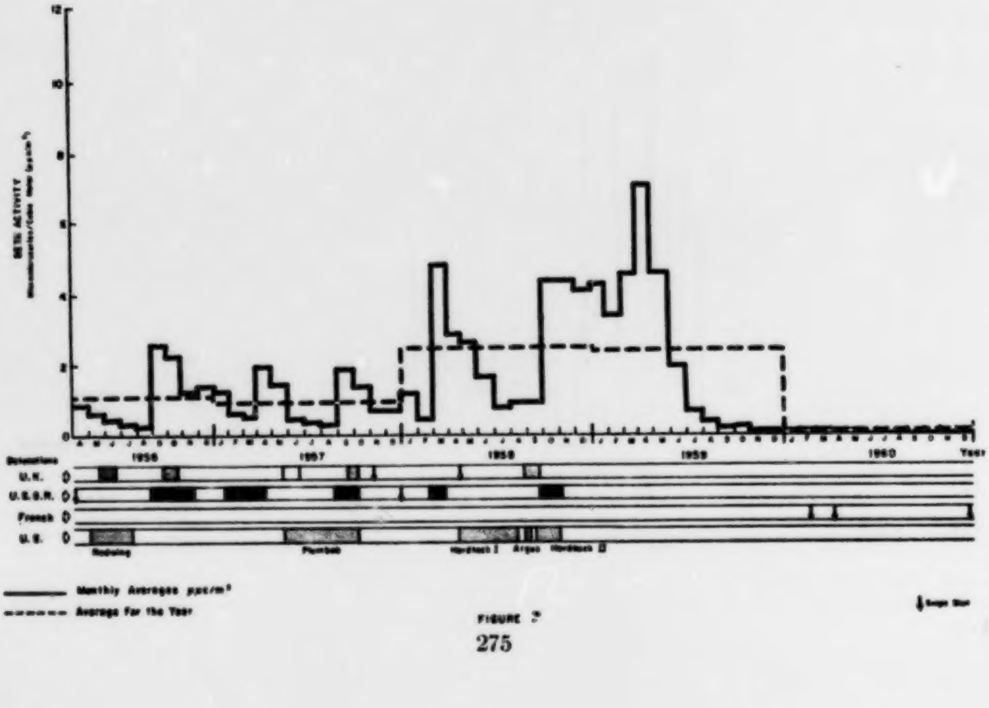

FIGURE 7

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BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Los Angeles, California

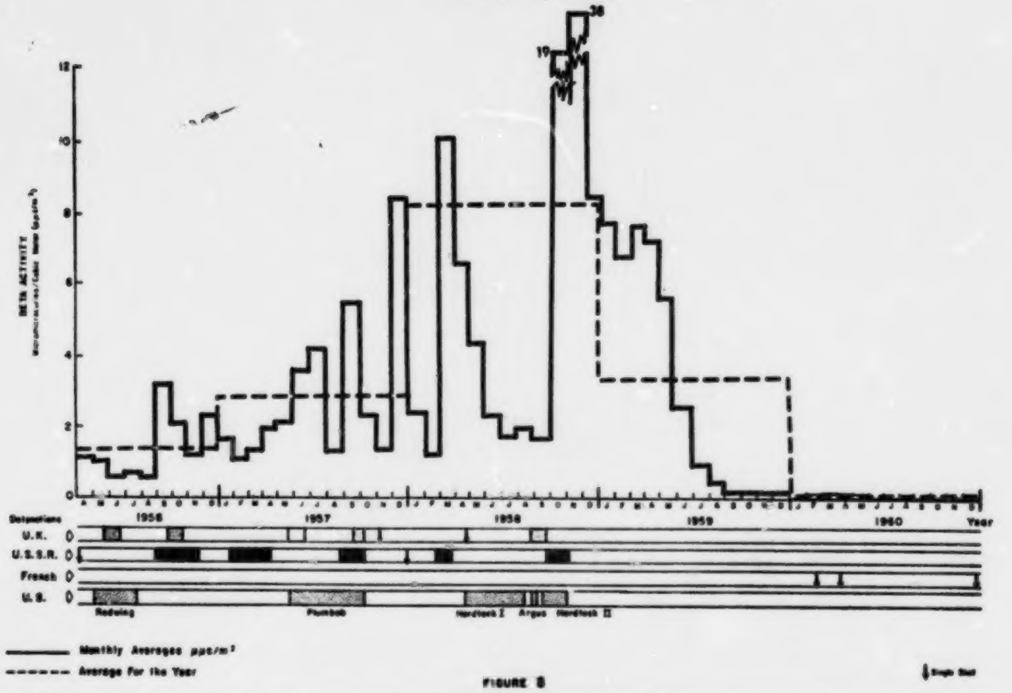

FIGURE 8

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Denver, Colorado

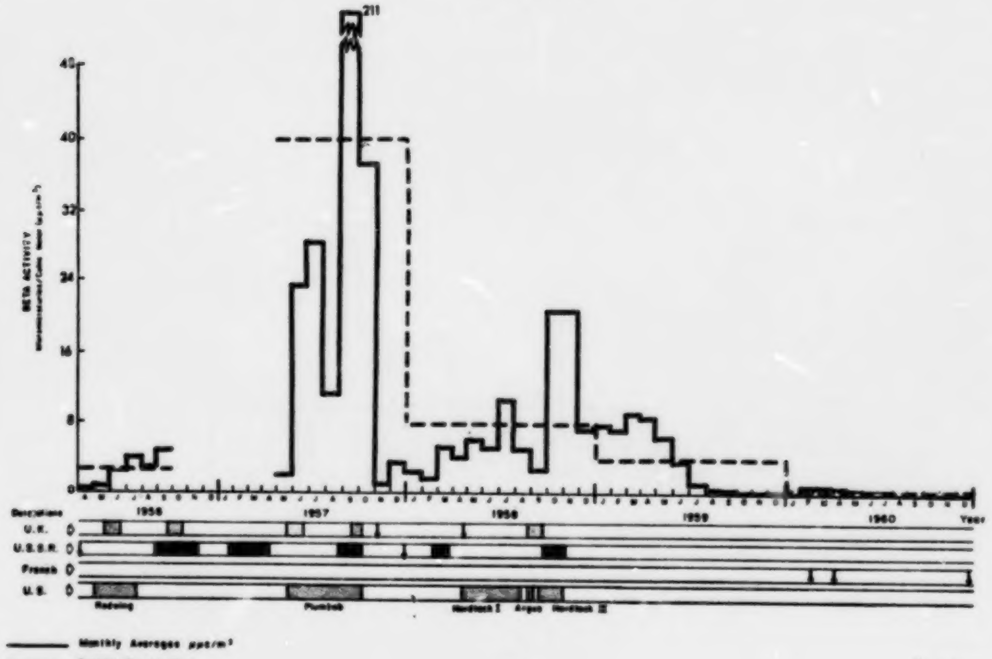

FIGURE 9

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BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Hartford, Connecticut

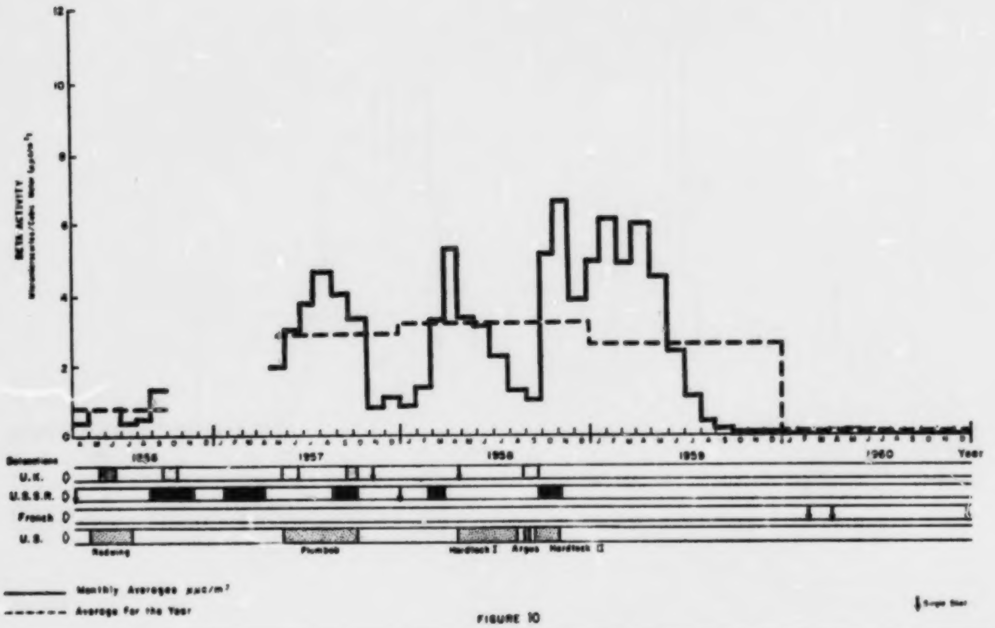

FIGURE 10

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

District of Columbia

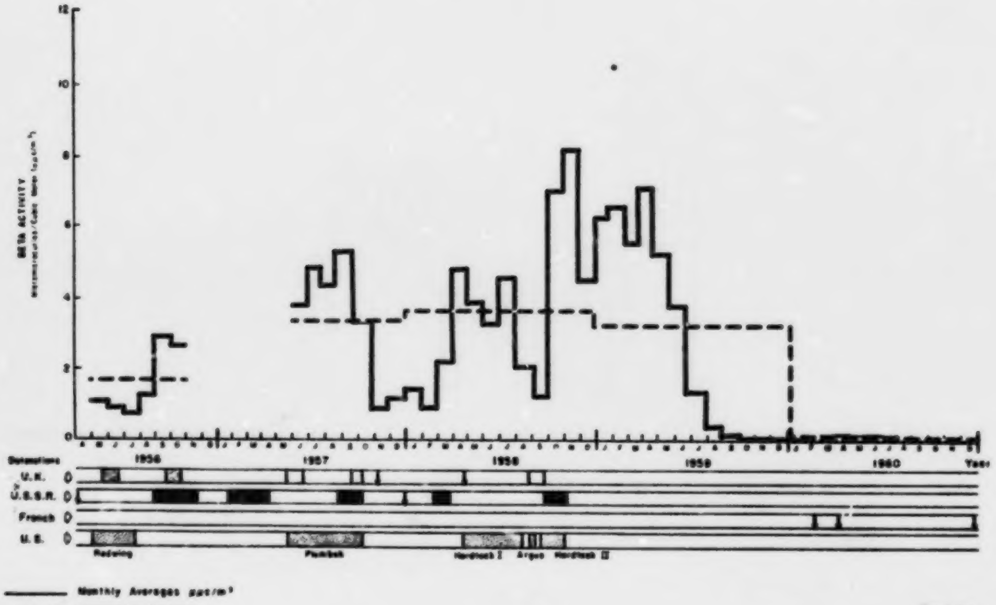

FIGURE 11

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BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Jacksonville, Florida

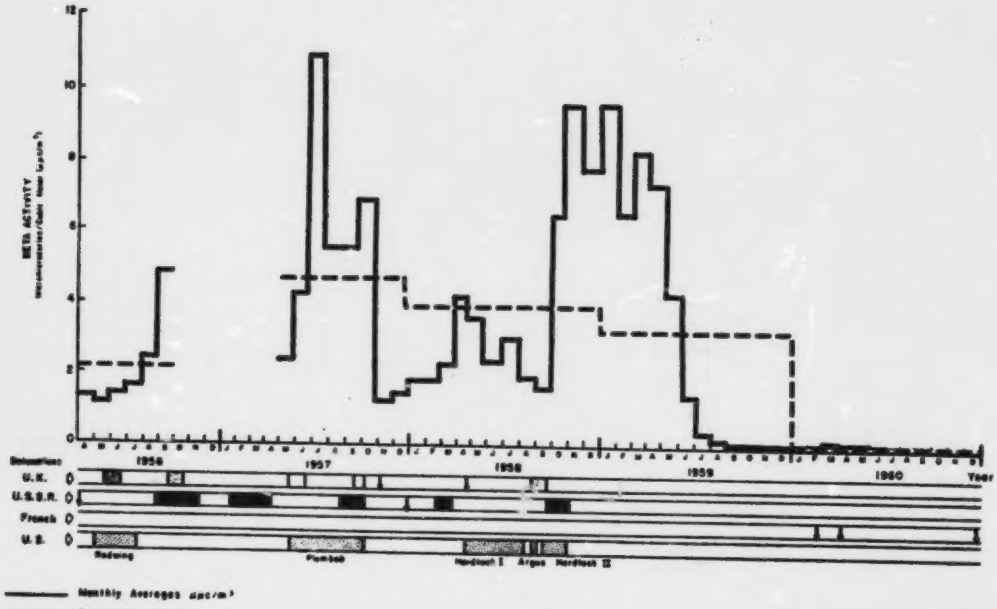

FIGURE 12

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Atlanta, Georgia

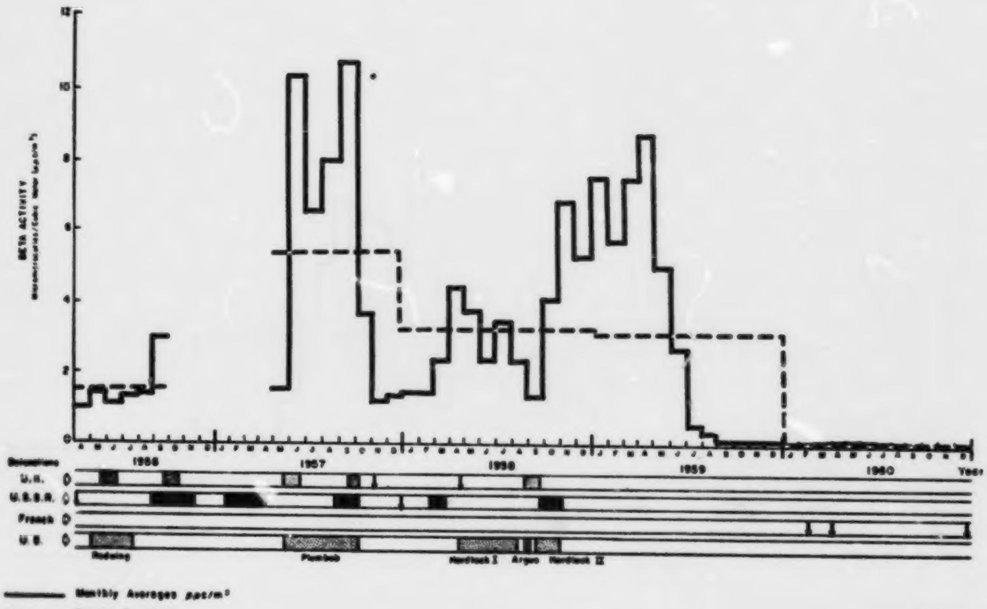

FIGURE 13

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BETA ACTIVITY OF AIR-BORNE PARTICULATES
RADIATION SURVEILLANCE NETWORK
Honolulu, Hawaii

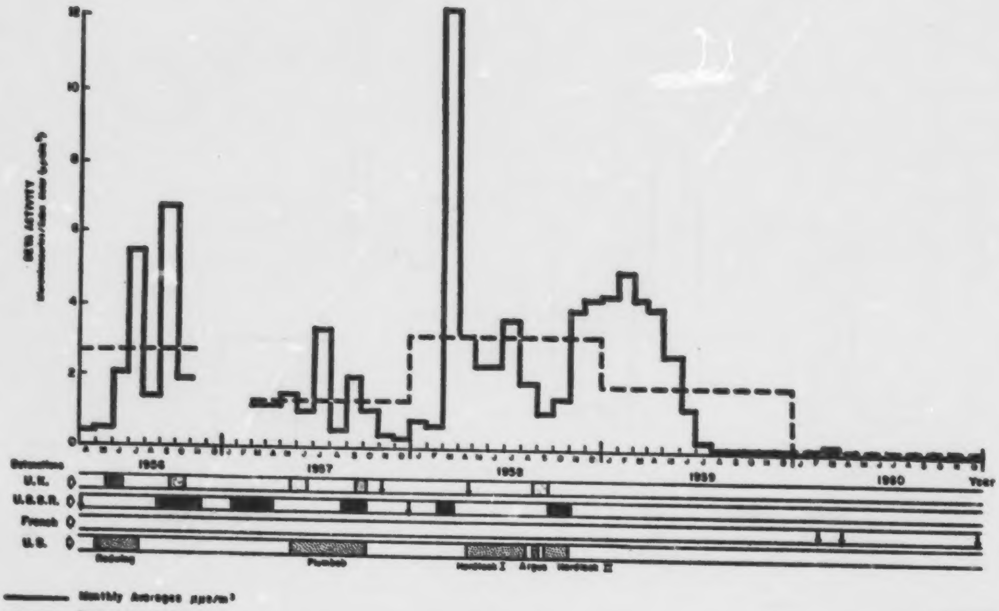

FIGURE 14

BETA ACTIVITY OF AIR-BORNE PARTICULATES
RADIATION SURVEILLANCE NETWORK
Boise, Idaho

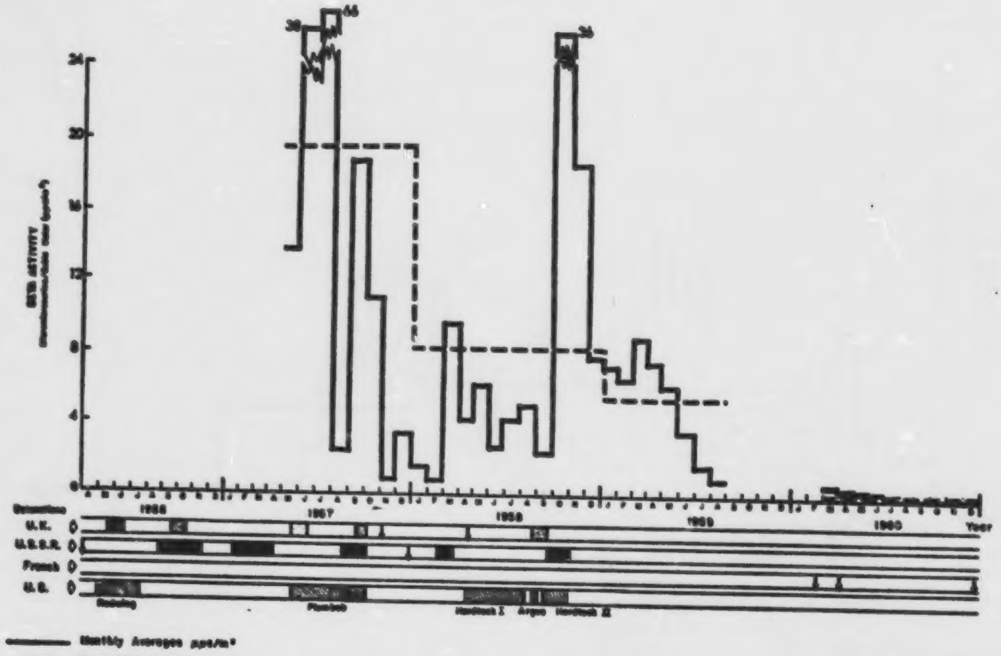

FIGURE 13

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BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Springfield, Illinois

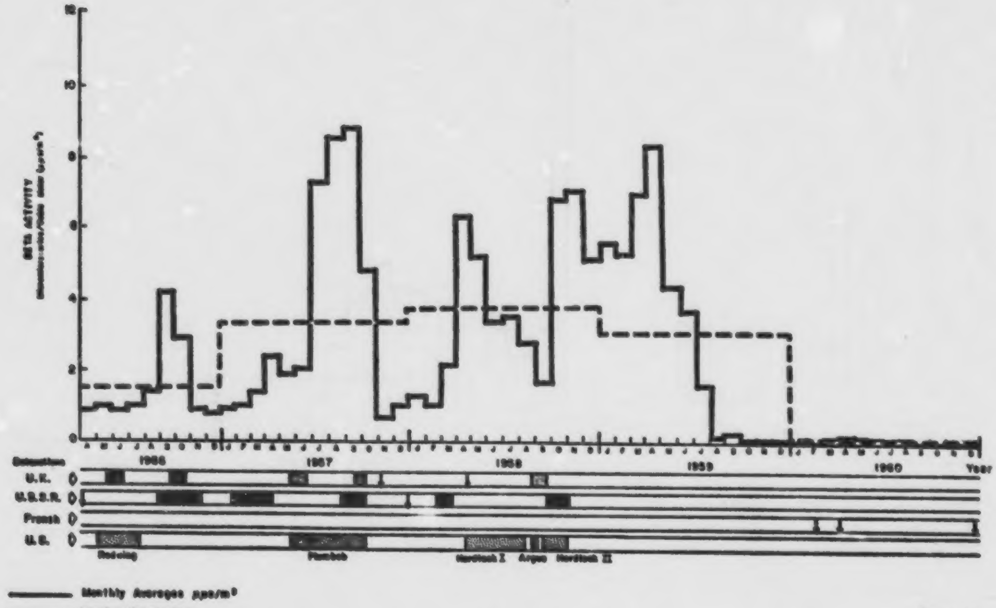

FIGURE 16

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Indianapolis, Indiana

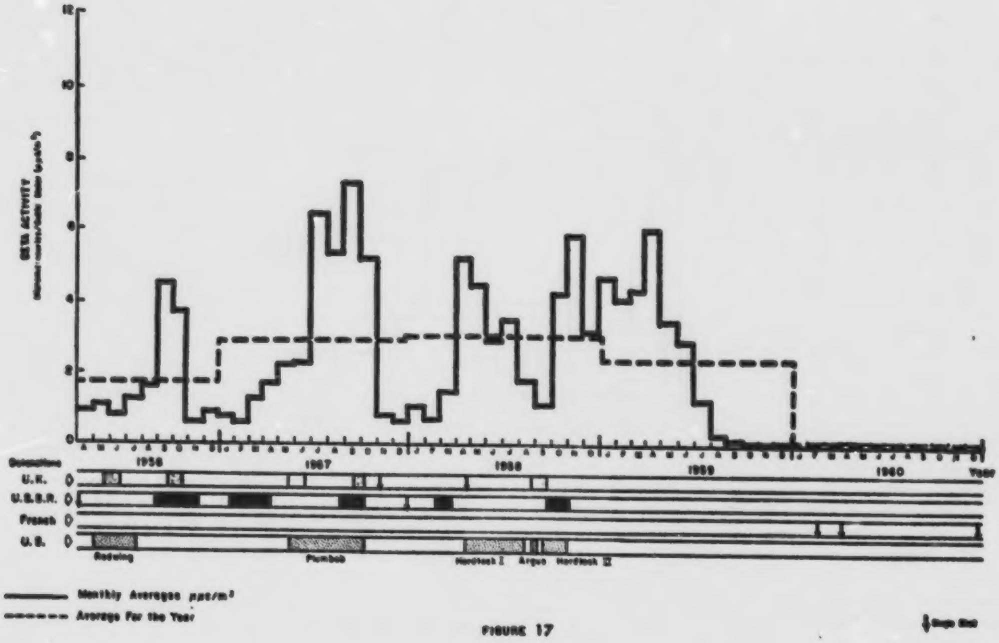

FIGURE 17

13<

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Iowa City, Iowa

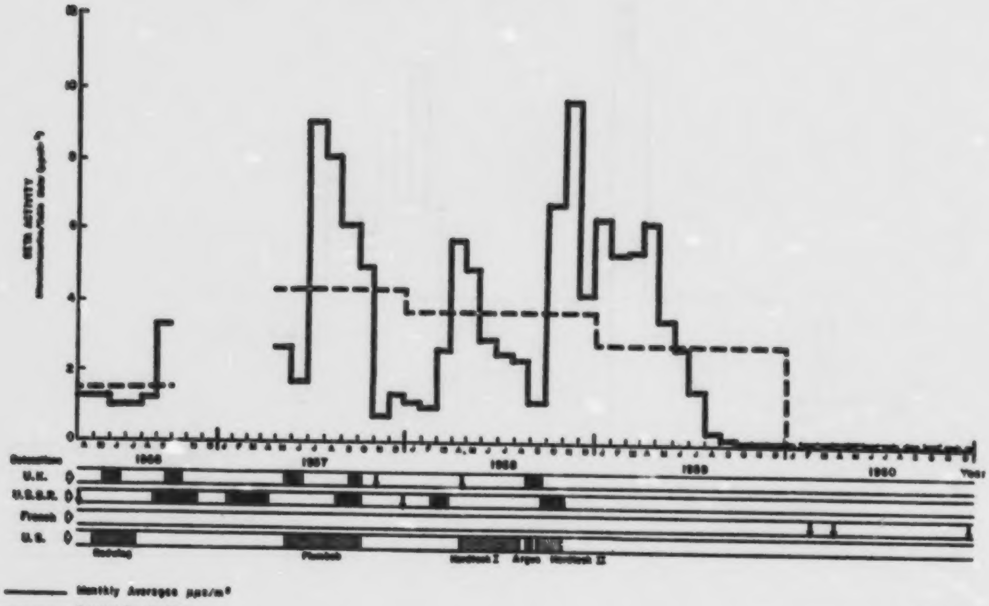

FIGURE 18

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Tapeka, Kansas

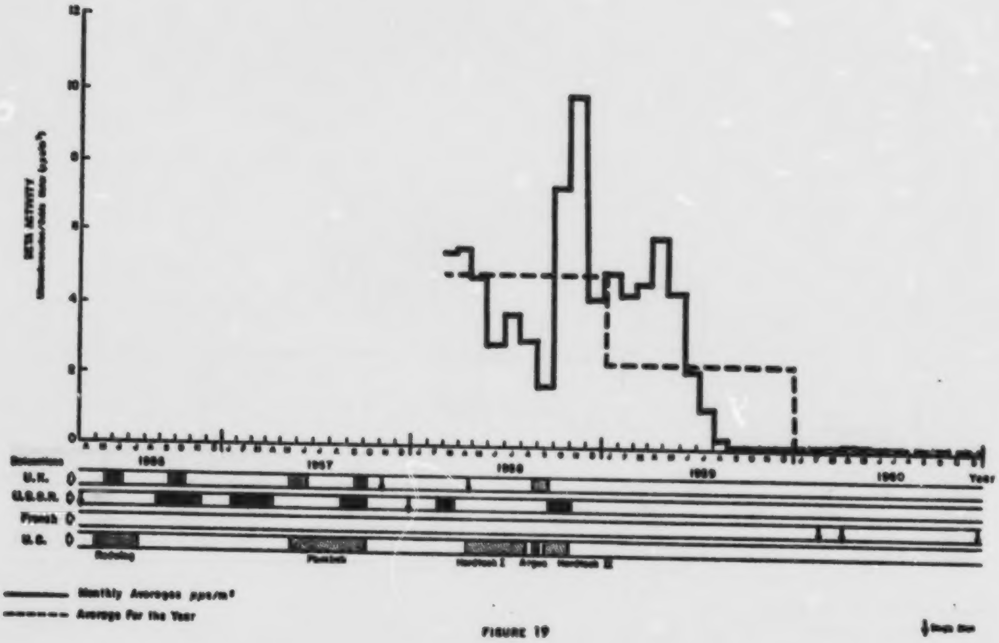

FIGURE 19

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BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

New Orleans, Louisiana

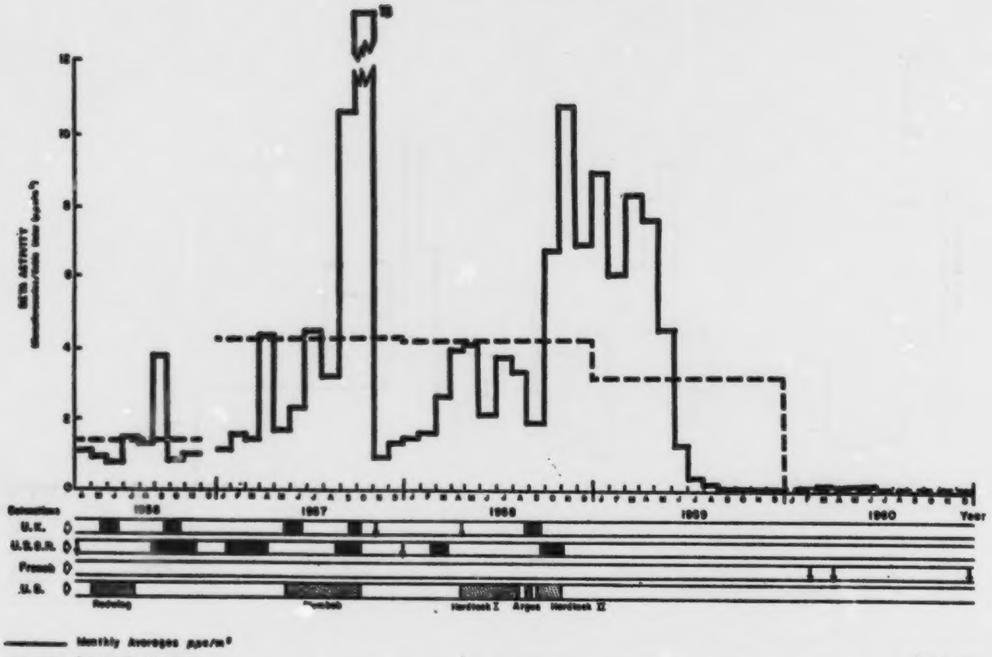

FIGURE 20

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Baltimore, Maryland

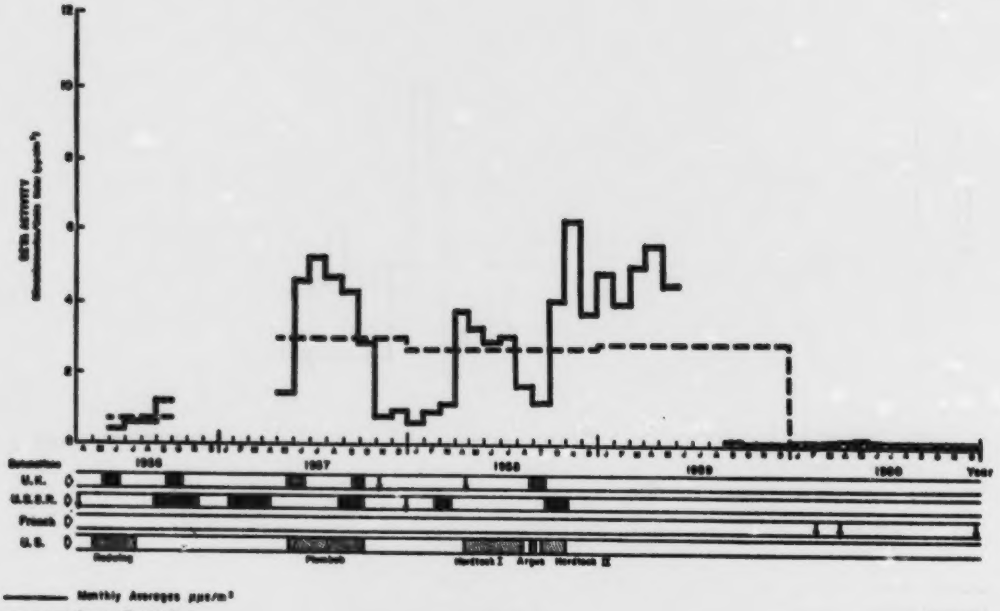

FIGURE 21

15<

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Lawrence, Massachusetts

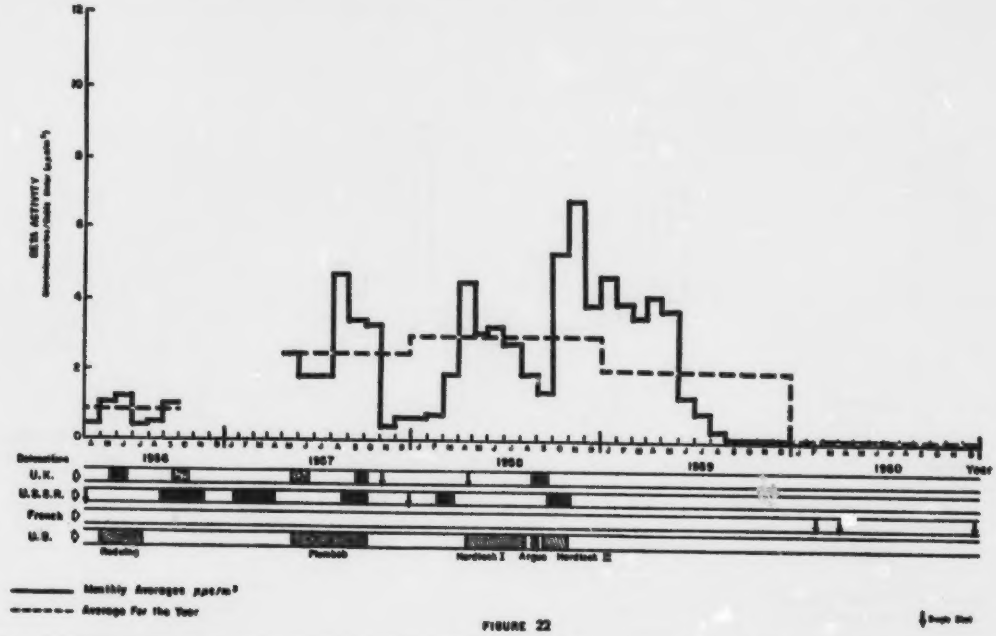

FIGURE 22

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Lansing, Michigan

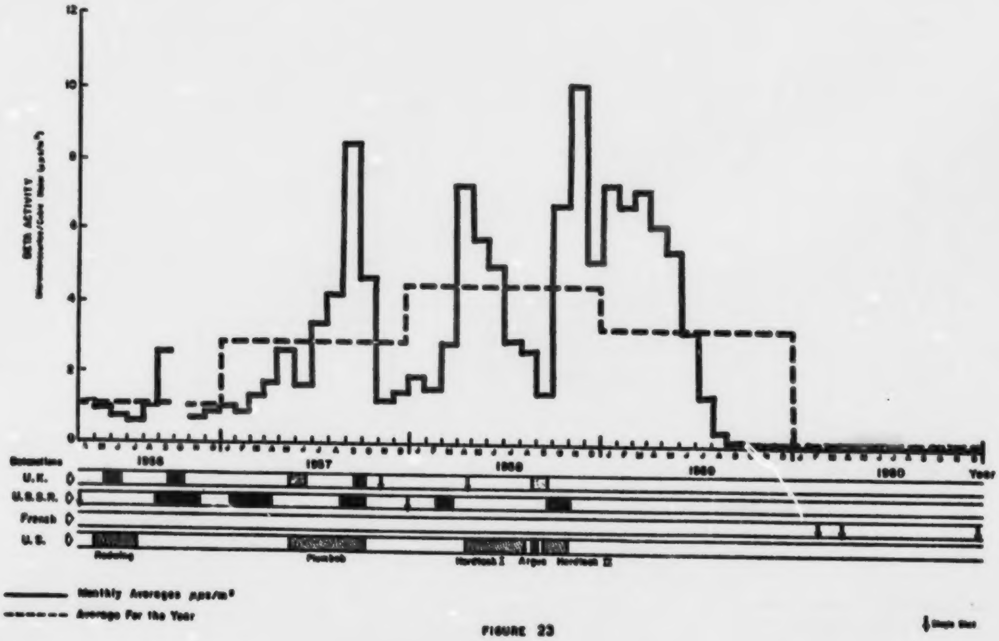

FIGURE 23

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BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Minneapolis, Minnesota

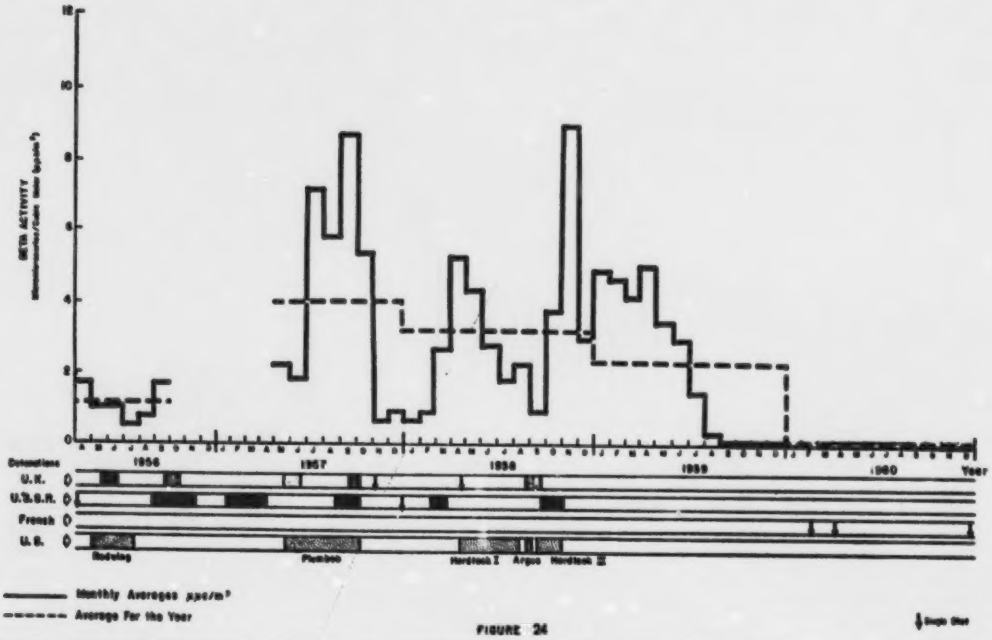

FIGURE 24

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Pascagoula, Mississippi

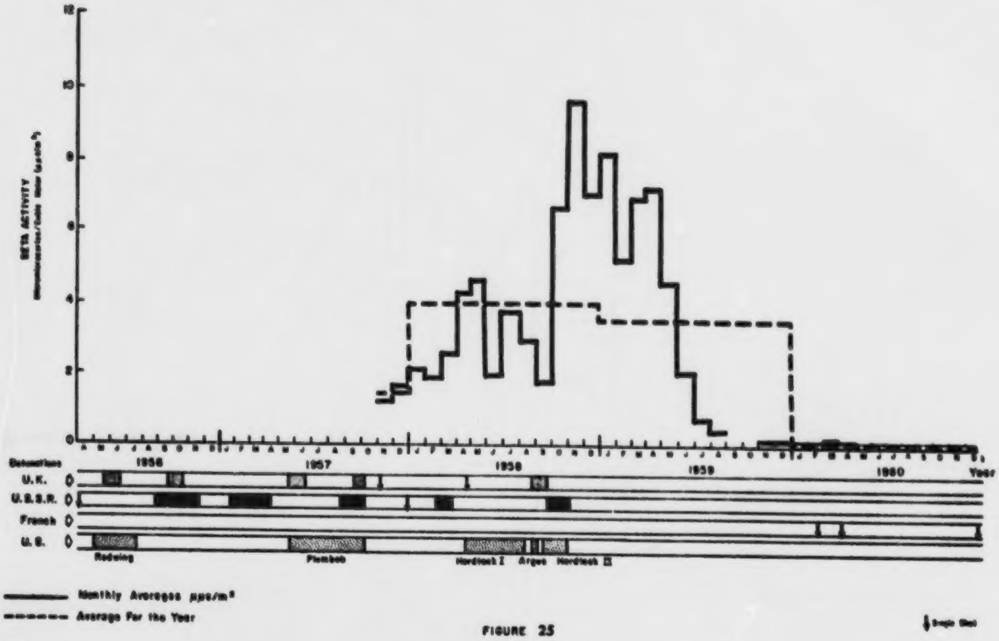

FIGURE 25

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Jefferson City, Missouri

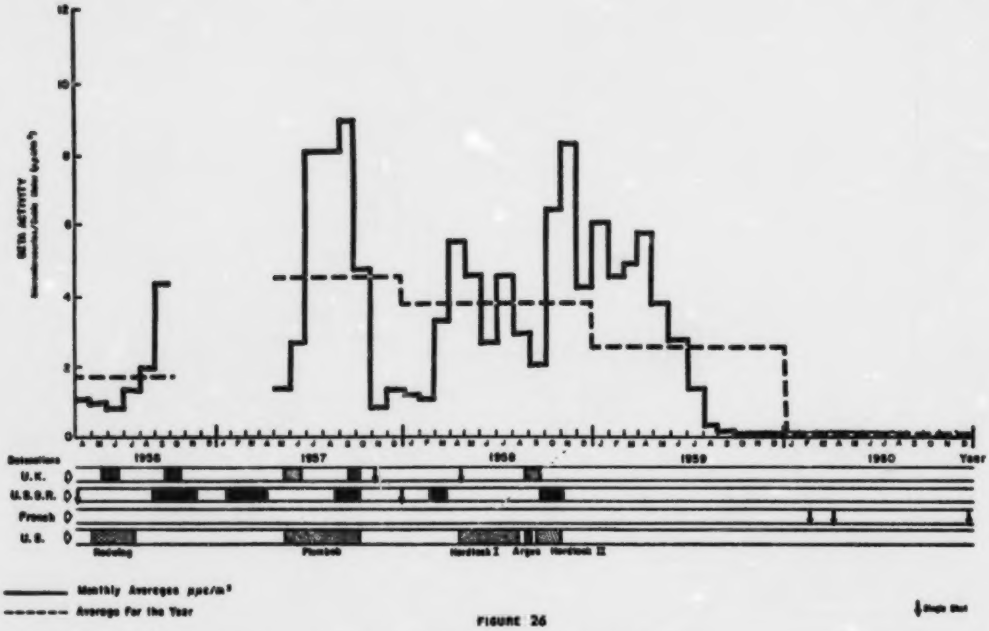

FIGURE 26

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Helena, Montana

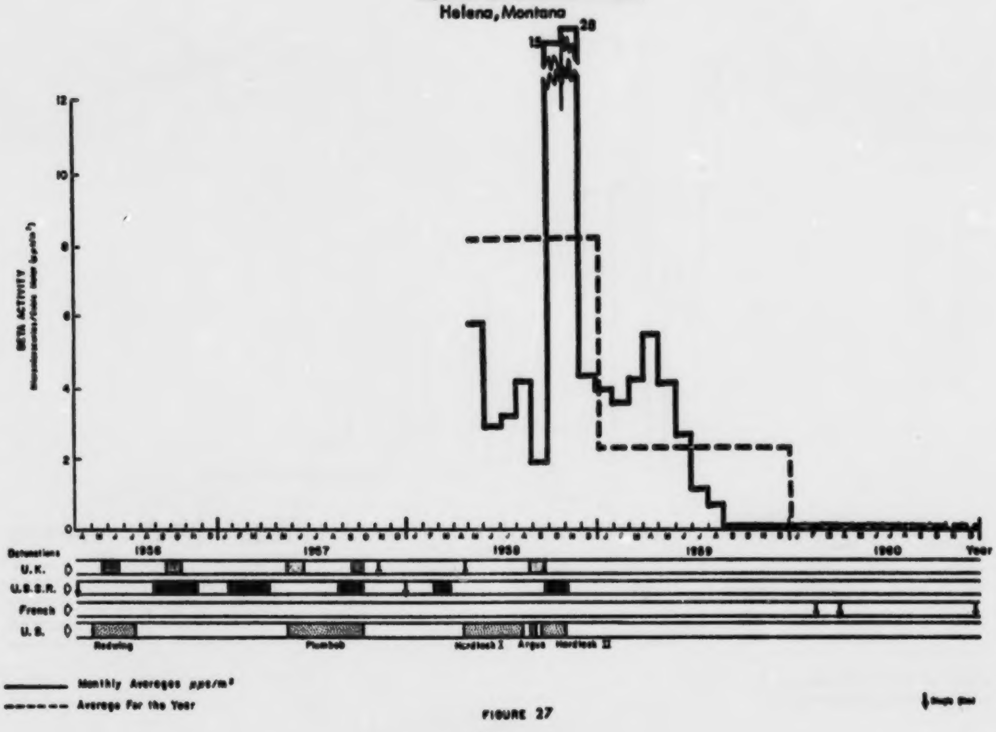

FIGURE 27

18<

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Trenton, New Jersey

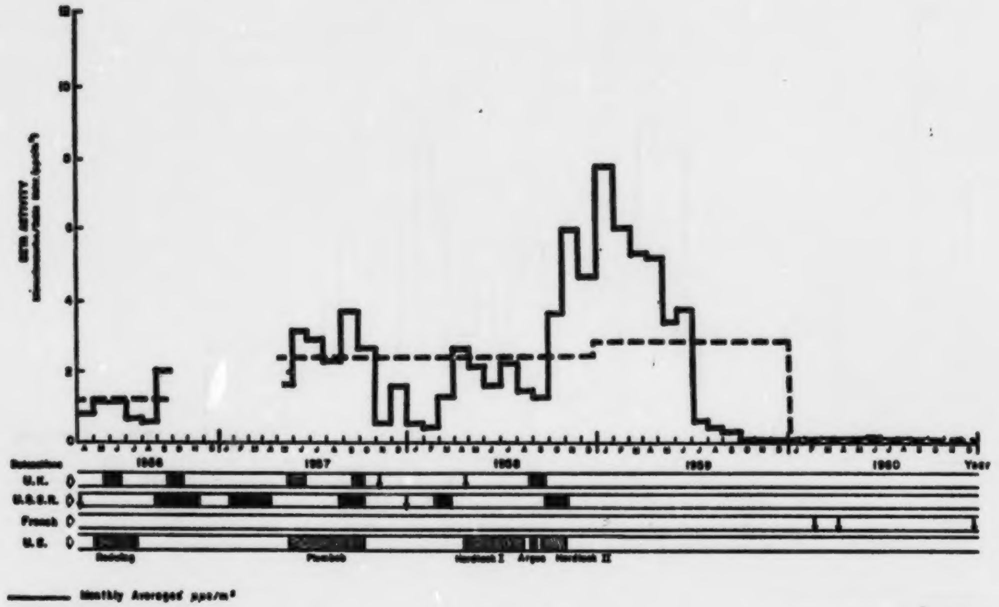

FIGURE 28

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Santa Fe, New Mexico

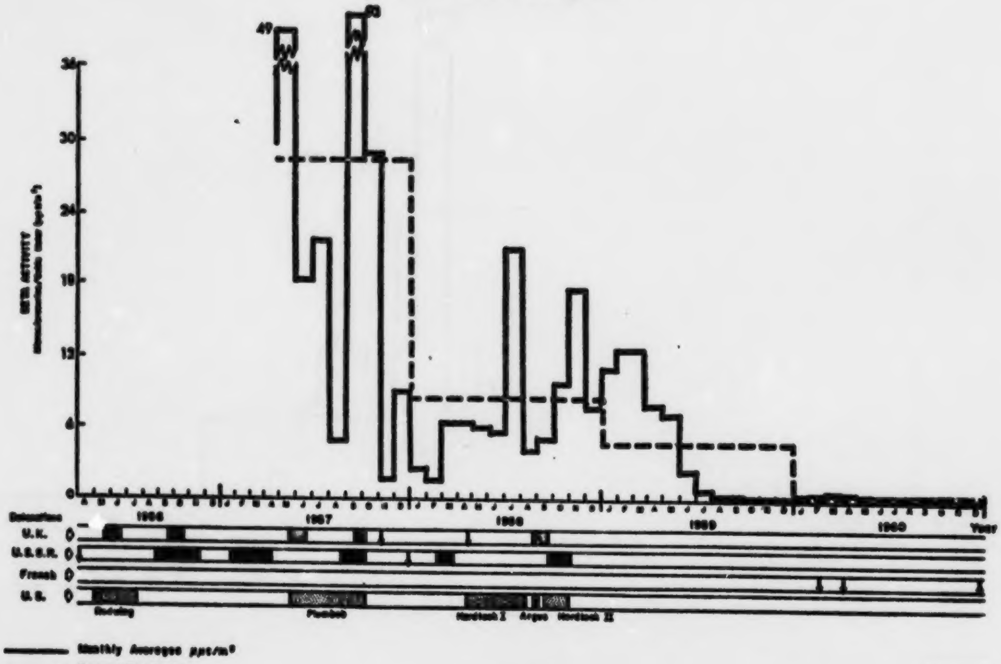

FIGURE 29

19<

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Albany, New York

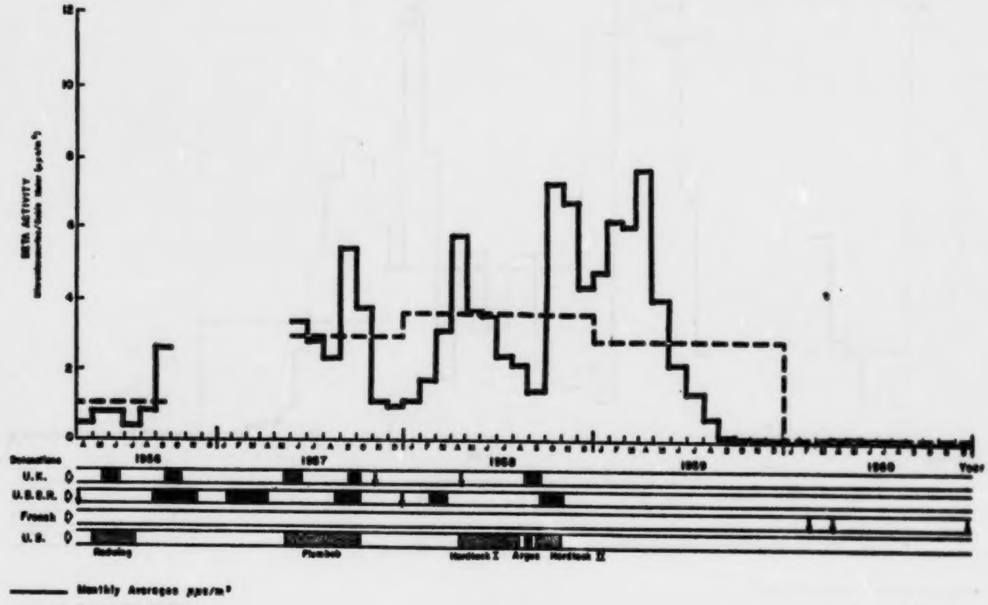

FIGURE 30

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Gastonia, North Carolina

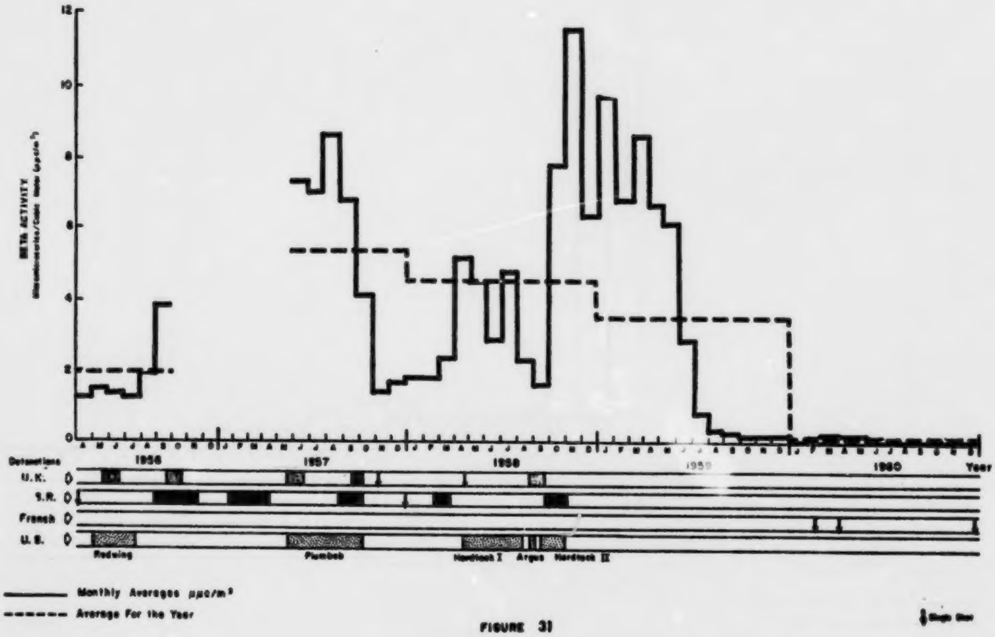

FIGURE 31

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Oklahoma City, Oklahoma

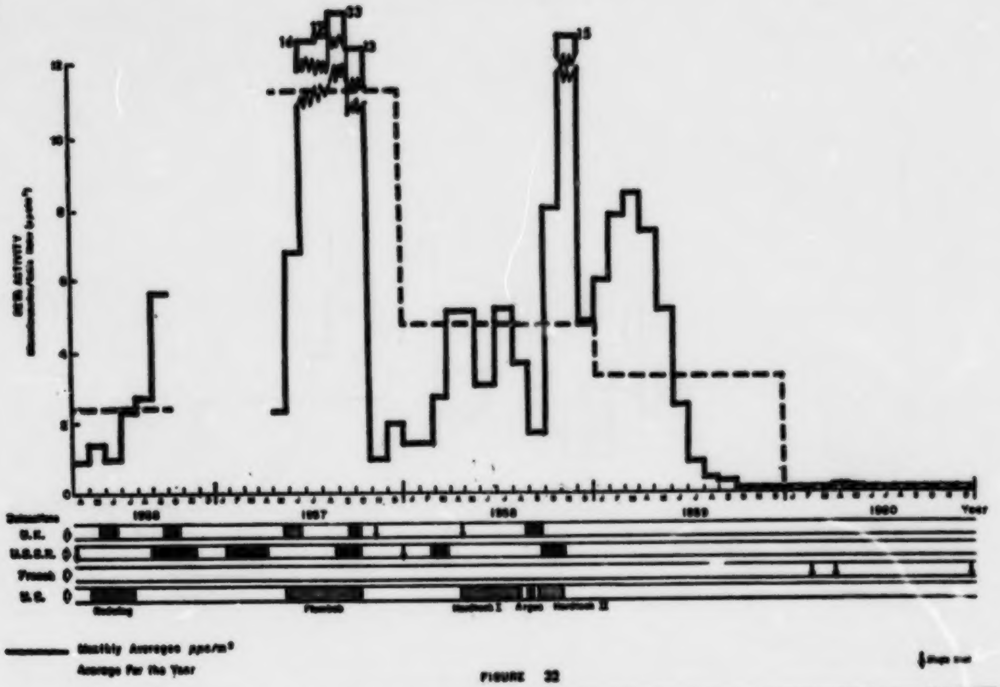

FIGURE 32

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Ponca City, Oklahoma

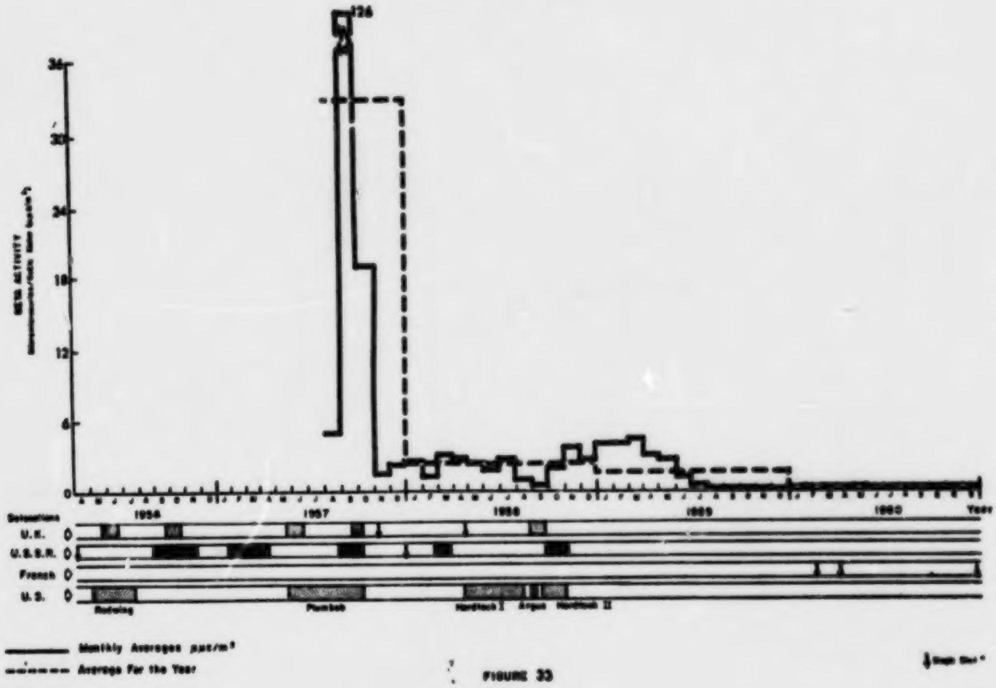

FIGURE 33

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BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Portland, Oregon

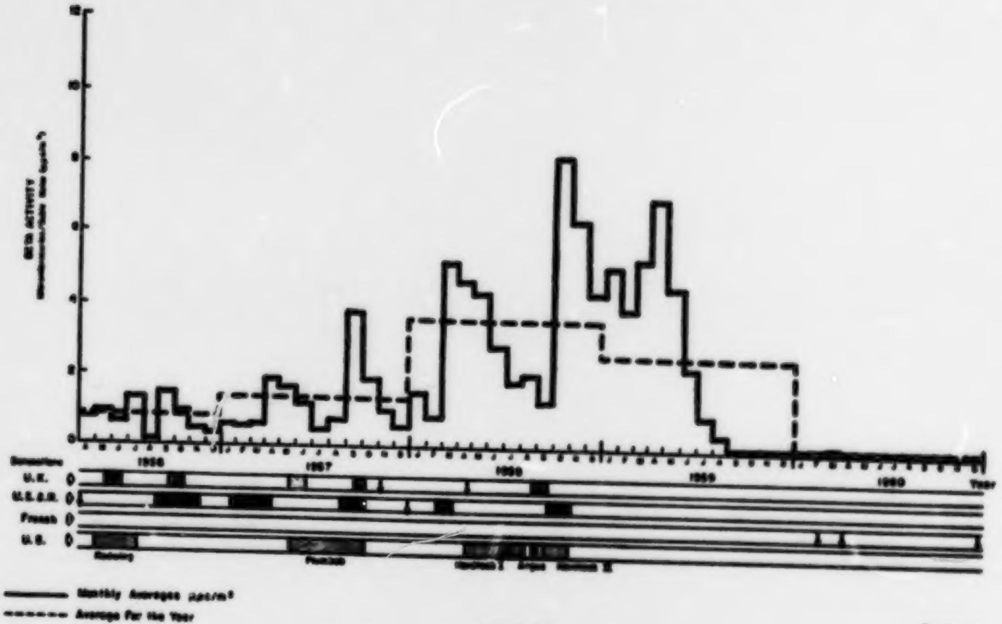

FIGURE 34

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Harrisburg, Pennsylvania

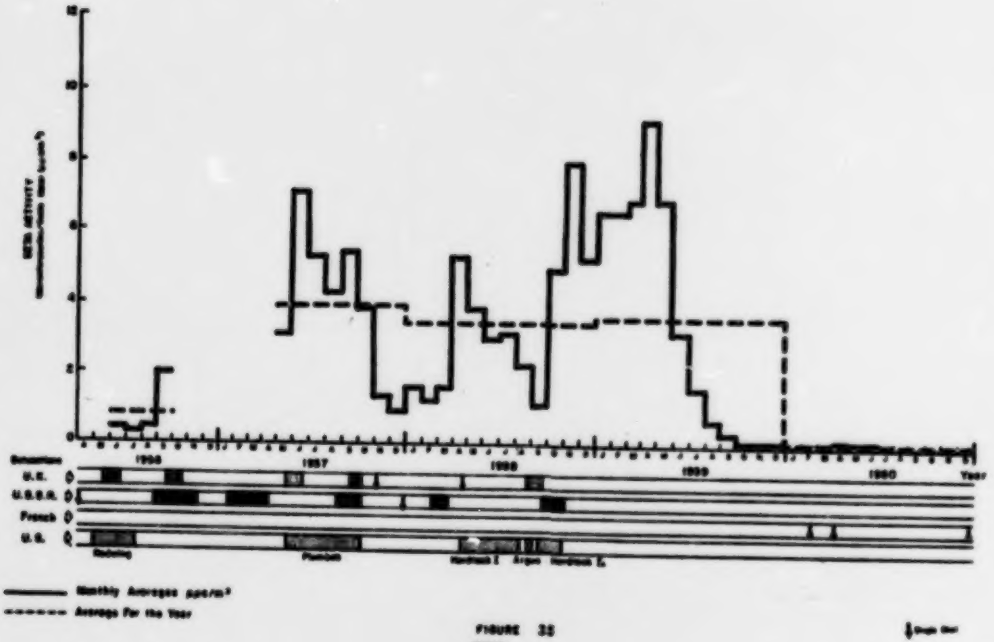

FIGURE 35

22<

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Providence, Rhode Island

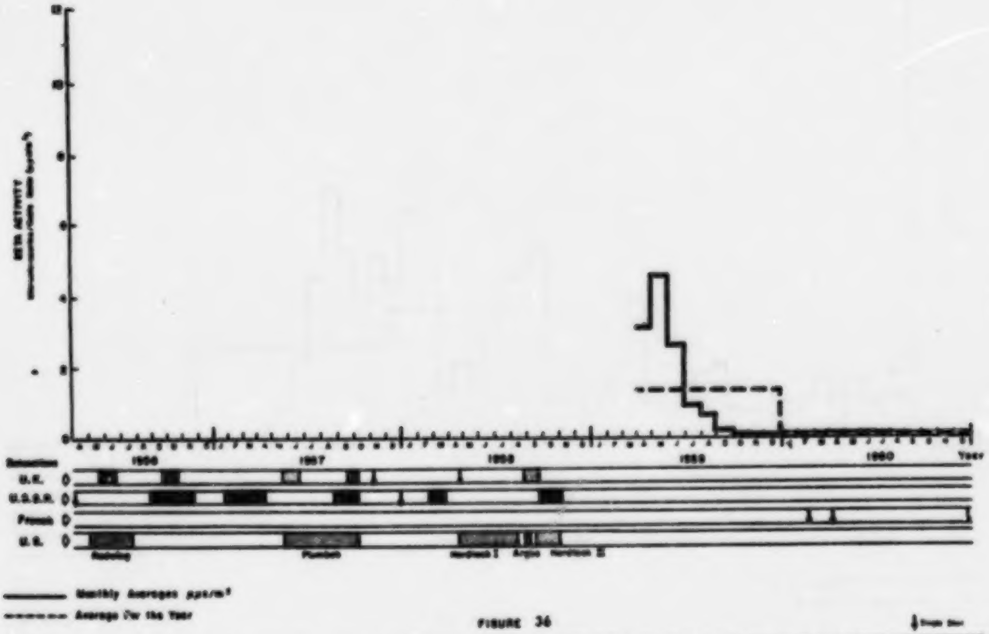

FIGURE 36

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Columbia, South Carolina

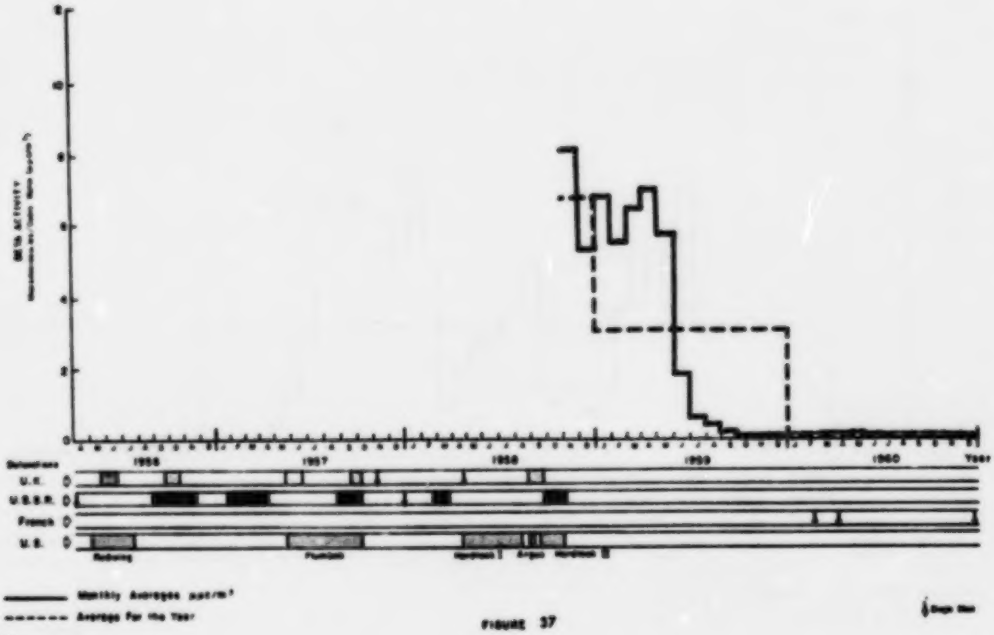

FIGURE 37

20-

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Pierre, South Dakota

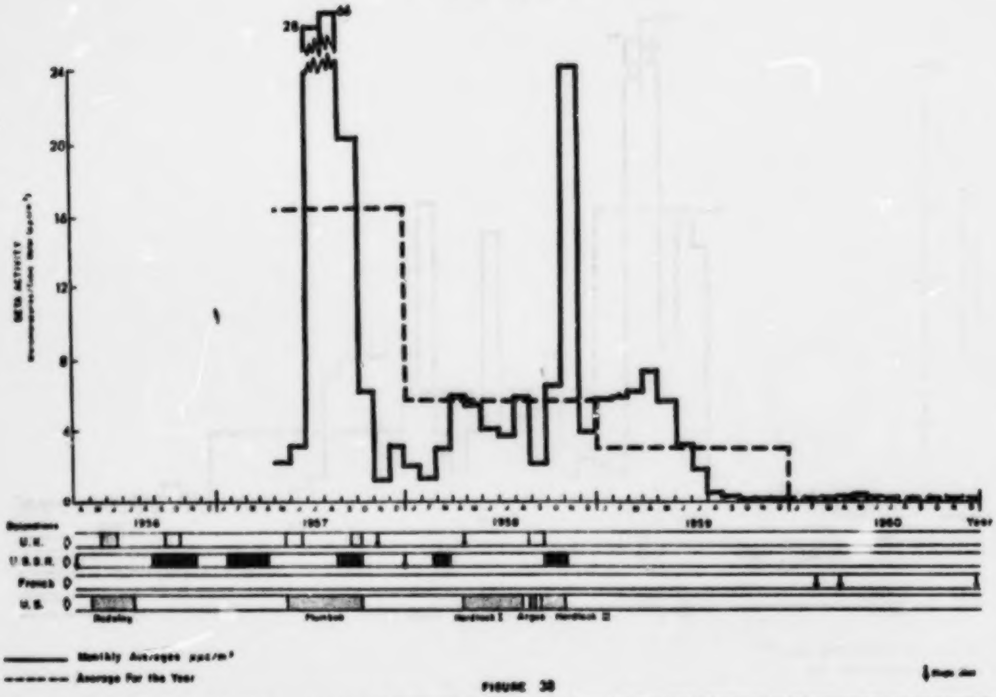

FIGURE 38

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Austin, Texas

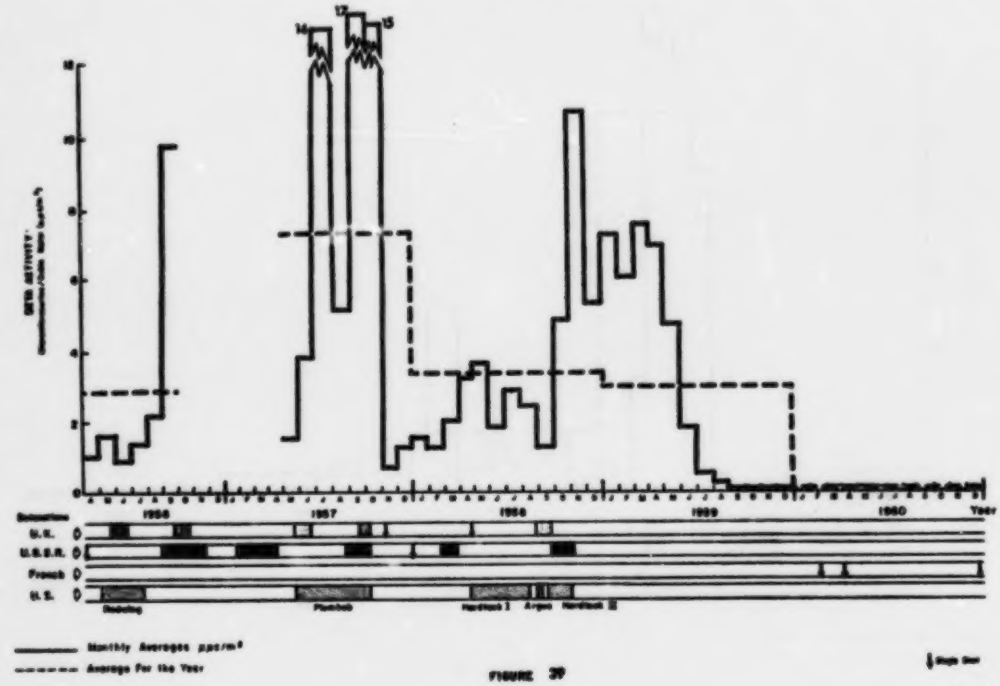

FIGURE 39

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

El Paso, Texas

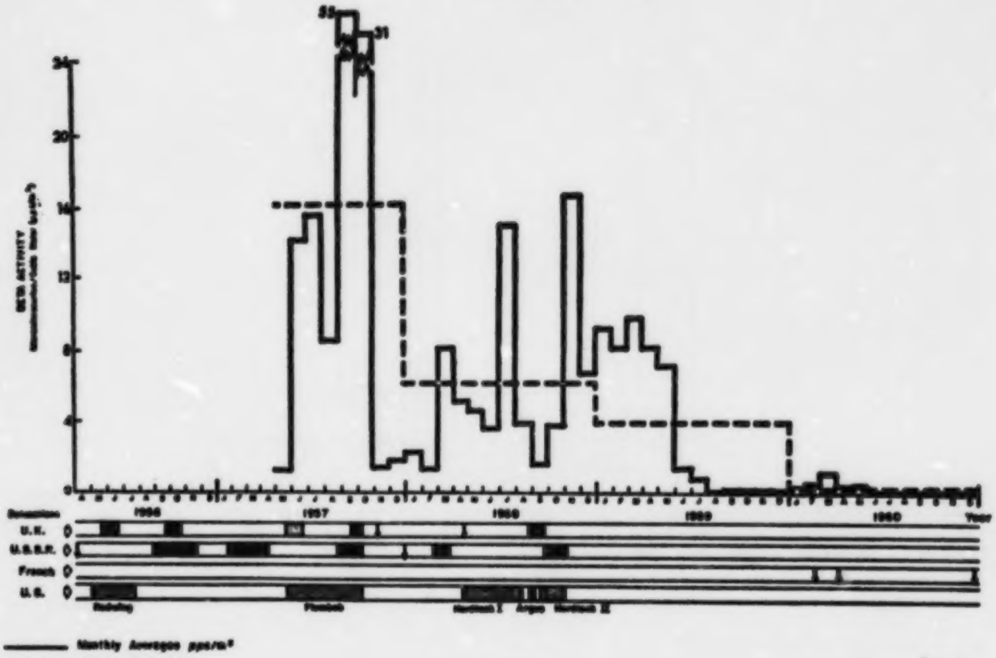

FIGURE 40

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Salt Lake City, Utah

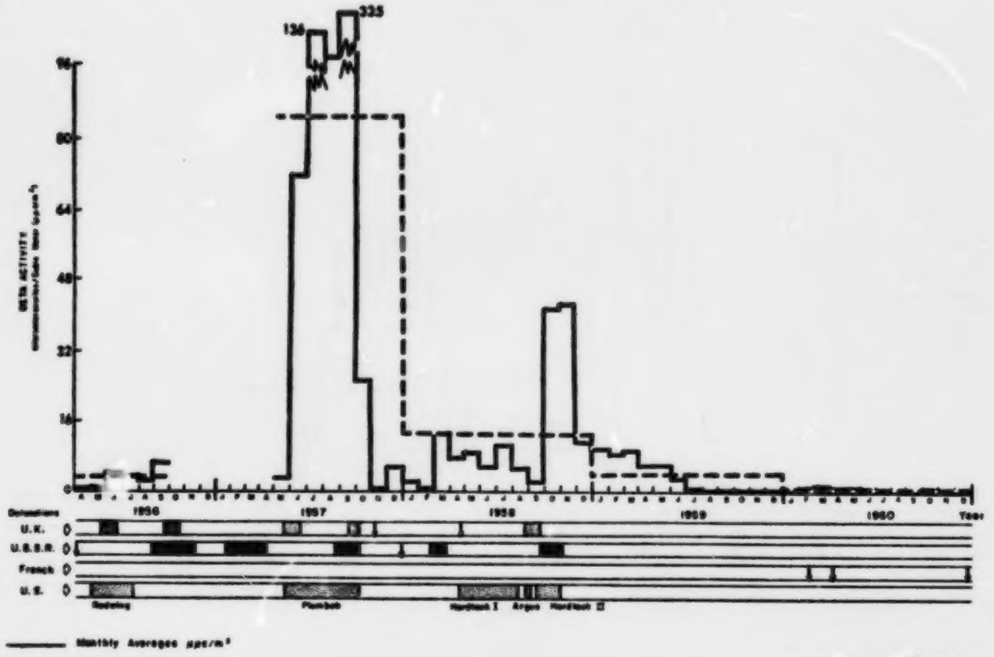

FIGURE 41

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Richmond, Virginia

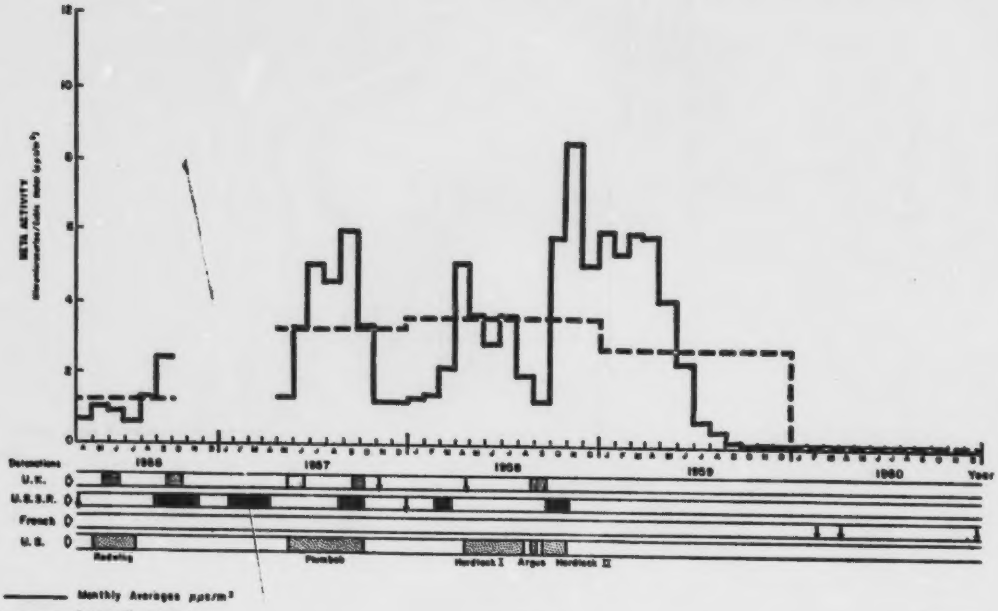

FIGURE 42

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Seattle, Washington

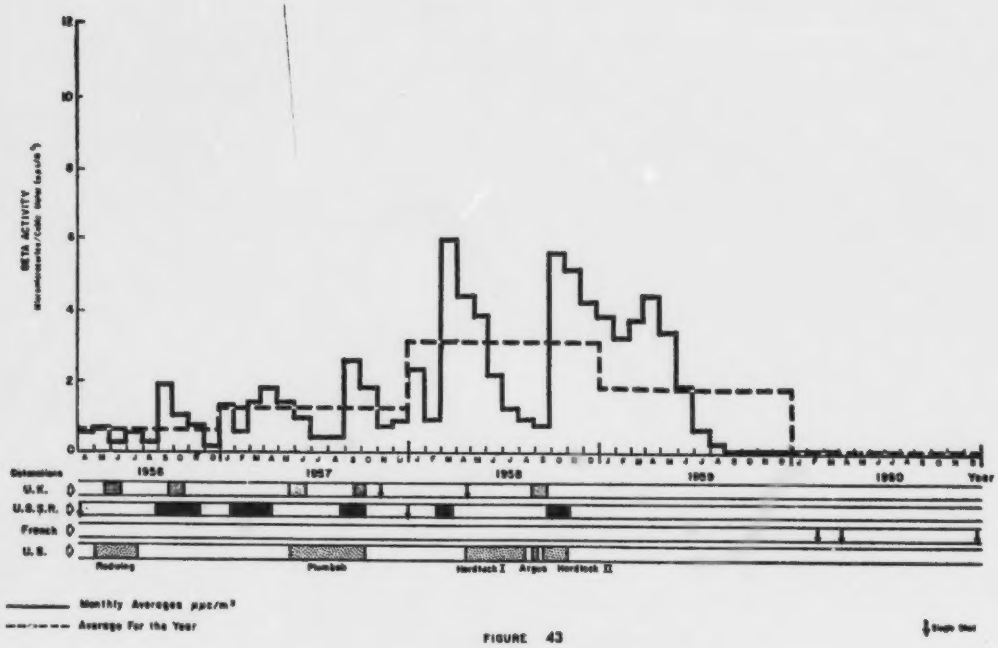

FIGURE 43

BETA ACTIVITY OF AIR-BORNE PARTICULATES

RADIATION SURVEILLANCE NETWORK

Cheyenne, Wyoming

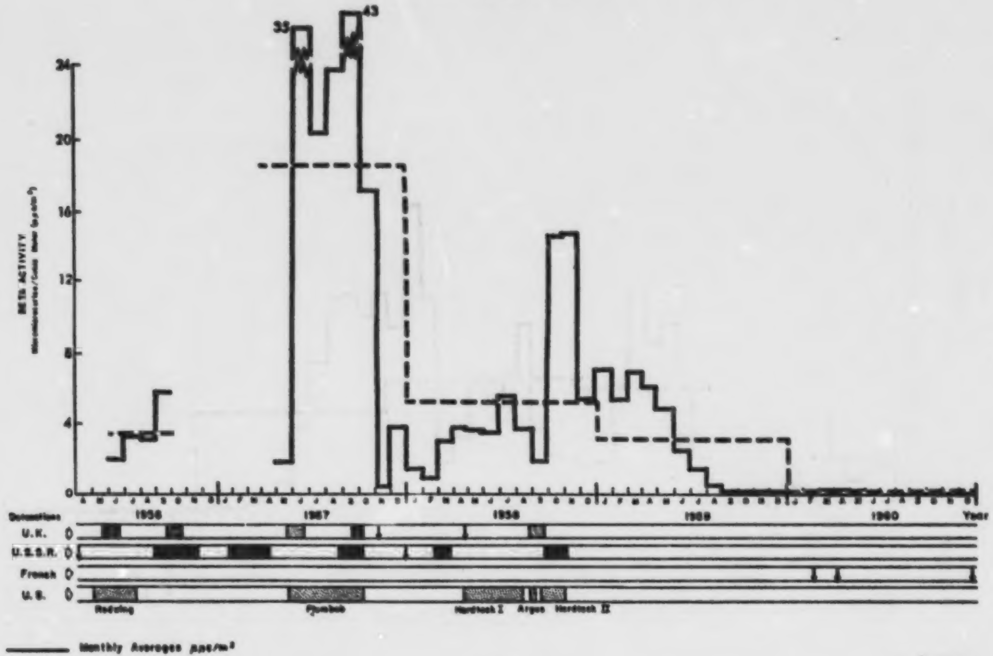

FIGURE 44

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Table 2.—RADON AND THORON MEASUREMENTS

Radiation Surveillance Network, Public Health Service, Station at Cincinnati, Ohio, February 2–24, 1961

Date	Continuous sample collection			Radon [a] a.m. ($\mu\mu c/m^3$)	Radon-thoron [b] p.m. ($\mu\mu c/m^3$)	Thoron [c] ($\mu\mu c/m^3$)	Beta activity [d] ($\mu\mu c/m^3$)
	Sample change time	Sample period (hours)	Volume (m^3)				
Feb. 2	0830	24.5	29.3	110	450	0.5	0.08
3	0801	23.5	28.1	200	110	0.3	0.04
6	0806	72.1	84.5	350	200	0.3	0.03
7	0805	24.0	28.0	230	120	0.2	0.02
8	0819	24.2	28.3	290	150	0.2	0.07
9	0813	23.9	28.0	530	250	0.8	0.07
10	0815	24.0	28.6	150	130	0.3	0.04
13	0817	72.0	84.2	270	250	0.7	0.07
14	0810	23.9	28.1	80	120	0.4	0.05
15	0814	24.0	28.5	510	100	2.8	0.03
16	0800	23.8	29.3	170	110	1.1	0.04
17	0809	24.1	28.7	340	140	2.9	0.07
20	0805	71.9	85.7	280	200	2.6	0.07
21	0805	24.0	28.9	240	110	1.4	0.06
23	0808	48.0	56.7	90	250	0.9	0.05
24	0806	24.0	28.9	230	80	2.3	0.13
			Average	254	173	1.11	0.06

[a] Radon concentrations are derived from alpha measurements determined immediately after the sampling period (24 to 72 hours) has ceased. Reported radon concentrations have been corrected for any thoron daughter interferences. Twice the standard deviation (2σ) falls between ±17 and ±40 $\mu\mu c/m^3$.

[b] Radon concentrations are derived from alpha measurements made in the afternoon (3 p.m.) approximately 7 hours after the new sampling period has begun. Therefore, the reported values were actually determined one day prior to the date reported here. Reported radon concentrations are uncorrected for any thoron daughter interferences. Twice the standard deviation (2σ) falls between ±15 and ±37 $\mu\mu c/m^3$.

[c] Thoron concentrations are derived from alpha measurements referred to in footnote (a) but are counted 7 hours after the sampling period has ceased. Reported values are corrected to the time of removal of the filter holder. Twice the standard deviation (2σ) falls between ±0.2 and ±0.6 $\mu\mu c/m^3$.

[d] Gross beta concentrations are based on measurements made at least 4 days after the end of each sampling period (24 to 72 hours). Twice the standard deviation (2σ) falls between ±0.01 and ±0.08 $\mu\mu c/m^3$.

National Air Sampling Network

Division of Air Pollution, Public Health Service

The Public Health Service developed its National Air Sampling Network in 1953 to secure basic data on the nature and extent of air pollution throughout the United States, and to detect trends in levels of pollution with respect to time, location, population density, climate, and other factors associated with air quality.

The current basic network consists of 103 sampling stations operating every year in 66 large cities and 37 nonurban areas. In addition to these every-year stations, 126 cities have stations which operate every other year. Thus, there are 229 sampling stations in all, of which about 166 are active in any given year. A list of National Air Sampling Network Stations appeared in *Radiological Health Data*, Volume 1, Number 2.

The network stations are manned by Federal, State, and local agencies cooperating with the Division of Air Pollution, PHS. Twenty-four hour samples of suspended particulate matter, representing approximately 2,000 cubic meters of air, are collected on glass fiber filters on a bi-weekly random sampling schedule. The analyses of these samples include the measurement of total quantity of suspended particulate matter, the organic matter soluble in benzene, and fission product gross beta radioactivity. Selected samples are analyzed also for nitrates and sulfates and for a number of metals.

Quarterly reports of individual sample data and annual summaries are distributed to all participating agencies and State health departments. A comprehensive report on the first five years of operation of the Network is contained in the publication, "Air Pollution Measurements of the National Air Sampling Network," Public Health Service Publication No. 637, 1958, for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., price $2.00. Gross beta activity data, by States, for the years 1953 through 1958 were submitted by Dr. F. J. Weber, Chief, Division of Radiological Health, Public Health Service, in testimony before the Joint Committee on Atomic Energy—"Hearings on Fallout from Nuclear Weapons Tests," Volume 1, May 1959, pages 173-185.

Previous data on gross beta activities of particulates in air were published in *Radiological Health Data,* Volume I, Numbers 7 and 8, and Volume II, Numbers 1 and 4. Data for the first quarter 1961 are presented in table 1.

FIGURE 1.—PUBLIC HEALTH SERVICE NATIONAL AIR SAMPLING NETWORK SAMPLING STATIONS

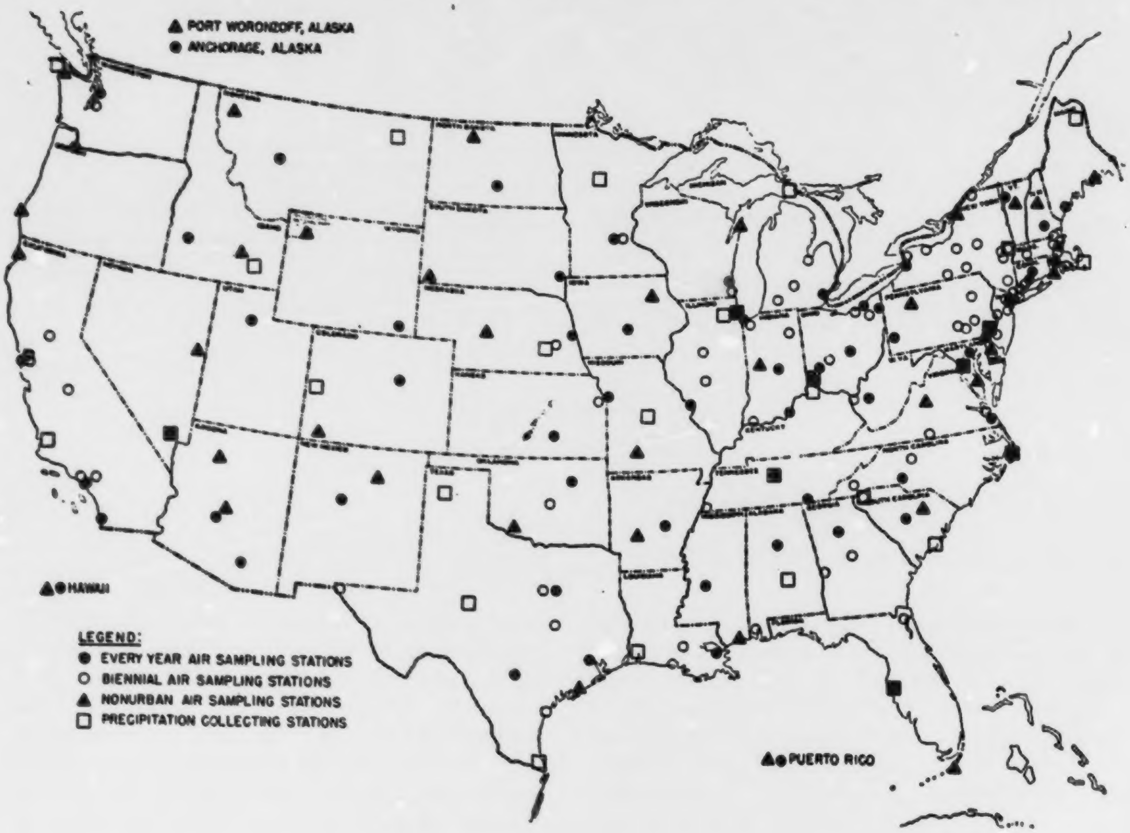
▲ PORT WORONZOFF, ALASKA
● ANCHORAGE, ALASKA
▲● HAWAII
▲● PUERTO RICO
LEGEND:
● EVERY YEAR AIR SAMPLING STATIONS
○ BIENNIAL AIR SAMPLING STATIONS
▲ NONURBAN AIR SAMPLING STATIONS
☐ PRECIPITATION COLLECTING STATIONS

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Table 1.—GROSS BETA RADIOACTIVITY IN AIR

National Air Sampling Network, Public Health Service, First Quarter 1961

[μμc per cubic meter]

Station location	Number of samples	Minimum	Maximum	Average
Waterbury, Conn	6	<0.1	0.1	<0.1
New Britain, Conn	6	<0.1	0.1	<0.1
Hartford, Conn	7	<0.1	0.1	<0.1
New Haven, Conn	6	<0.1	0.1	<0.1
Portland, Maine	6	<0.1	0.1	0.1
Acadia Nat. Pk., Maine [1]	6	<0.1	0.1	0.1
Boston, Mass	6	<0.1	0.1	0.1
Worcester, Mass	6	<0.1	0.1	<0.1
Brockton, Mass	6	<0.1	0.1	<0.1
Cambridge, Mass	8	<0.1	0.1	0.1
Lowell, Mass	6	<0.1	0.1	0.1
New Bedford, Mass	7	<0.1	0.1	<0.1
Manchester, N. H	6	<0.1	<0.1	<0.1
Coos County, N. H	6	<0.1	0.1	<0.1
Providence, R. I	8	<0.1	0.1	0.1
Washington, Co., R. I. [1]	6	<0.1	0.1	<0.1
Burlington, Vt	6	<0.1	0.1	0.1
Orange County, Vt. [1]	6	<0.1	0.1	0.1
Wilmington, Del	6	<0.1	0.1	<0.1
Kent County, Del [1]	5	<0.1	0.1	<0.1
Atlantic City, N. J	8	<0.1	0.1	0.1
Jersey City, N. J	6	<0.1	0.1	<0.1
Newark, N. J	7	<0.1	0.1	<0.1
Paterson, N. J	5	<0.1	0.1	0.1
New York, N. Y	6	<0.1	0.1	<0.1
Binghamton, N. Y	6	<0.1	0.1	0.1
Syracuse, N. Y	8	<0.1	0.1	<0.1
Utica, N. Y	5	<0.1	0.1	<0.1
Albany, N. Y	6	<0.1	0.1	<0.1
Rochester, N. Y	6	<0.1	0.1	<0.1
Niagara Falls, N. Y	6	<0.1	0.1	0.1
New Rochelle, N. Y	7	<0.1	0.1	0.1
Troy, N. Y	6	<0.1	0.1	0.1
Massena, N. Y	7	<0.1	<0.1	<0.1
Glen Cove, N. Y	5	<0.1	<0.1	<0.1
Elmira, N. Y	6	<0.1	0.1	<0.1
Mt. Vernon, N. Y	8	<0.1	0.1	<0.1
Cape Vincent, N. Y	8	<0.1	0.1	<0.1
Philadelphia, Pa	8	<0.1	0.1	<0.1
Altoona, Pa	4	<0.1	<0.1	<0.1
Erie, Pa	[illegible]	<0.1	0.1	<0.1
Pittsburgh, Pa	8	<0.1	0.1	0.1
Allentown, Pa	8	<0.1	0.1	0.1
Johnstown, Pa	5	<0.1	0.1	<0.1
Scranton, Pa	7	<0.1	0.1	0.1
York, Pa	8	<0.1	0.1	<0.1
Bethlehem, Pa	5	<0.1	0.1	<0.1
Clarion County, Pa [1]	7	<0.1	0.1	0.1
Washington, D. C	6	<0.1	0.1	<0.1
Louisville, Ky	6	<0.1	0.1	0.1
Baltimore, Md	5	<0.1	0.1	0.1
Calvert County, Md [1]	6	<0.1	0.1	<0.1
Charlotte, N. C	7	<0.1	0.2	0.1
Greensboro, N. C	7	<0.1	0.1	0.1
Raleigh, N. C	6	<0.1	0.1	0.1
Cape Hatteras, N. C [1]	8	<0.1	0.1	<0.1
San Juan, P. R	6	<0.1	0.1	<0.1
Loquillo, Mtns., P. R. [1]	6	<0.1	0.1	<0.1
Norfolk, Va	7	<0.1	0.1	0.1
Richmond, Va	7	<0.1	0.2	0.1
Hampton, Va	7	<0.1	0.1	0.1
Roanoke, Va	6	<0.1	0.1	0.1
Portsmouth, Va	8	<0.1	0.1	<0.1
Shenandoah, National Park, Va [1]	7	<0.1	0.1	<0.1
Charleston, W. Va	7	<0.1	0.3	0.1
Wheeling, W. Va	7	<0.1	0.1	<0.1
Birmingham, Ala	7	<0.1	0.1	0.1
Montgomery, Ala	7	<0.1	0.1	0.1
Tampa, Fla	7	<0.1	0.1	0.1
Miami, Fla	8	<0.1	0.1	<0.1
Orlando, Fla	6	<0.1	0.1	0.1
St. Petersburg, Fla	6	<0.1	0.1	0.1
Florida Keys, Fla [1]	6	<0.1	0.1	<0.1
Atlanta, Ga	7	<0.1	0.1	0.1
Augusta, Ga	6	<0.1	0.1	<0.1
Savannah, Ga	7	<0.1	0.1	0.1
Jackson, Miss	6	<0.1	0.1	<0.1
Jackson County, Miss [1]	6	<0.1	0.1	.1
Columbia, S. C	6	<0.1	0.1	0.1
Charleston, S. C	7	<0.1	0.2	0.1
Richland, County, S. C [1]	6	<0.1	0.1	0.1
Chattanooga, Tenn	7	<0.1	0.1	0.1
Knoxville, Tenn	6	<0.1	0.1	0.1
Nashville, Tenn	7	<0.1	0.1	0.1
Memphis, Tenn	7	<0.1	0.1	<0.1
Chicago, Ill	6	<0.1	0.1	0.1
East St. Louis, Ill	8	<0.1	0.1	0.1
Rockford, Ill	7	<0.1	0.1	<0.1
East Chicago, Ind	5	<0.1	0.1	0.1
Indianapolis, Ind	6	<0.1	0.1	0.1
Terre Haute, Ind	7	<0.1	0.1	<0.1
Hammond, Ind	7	<0.1	0.1	<0.1
South Bend, Ind	8	<0.1	0.1	<0.1
New Albany, Ind	6	<0.1	0.1	0.1
Montgomery County, Ind [1]	6	<0.1	0.1	0.1
Detroit, Mich	6	<0.1	0.1	0.1
Jackson, Mich	6	<0.1	0.1	0.1
Dearborn, Mich	6	<0.1	0.1	0.1
Cincinnati, Ohio	6	<0.1	0.1	0.1
Youngstown, Ohio	8	<0.1	0.1	<0.1
Canton, Ohio	7	<0.1	0.1	<0.1
Cleveland, Ohio	6	<0.1	0.1	0.1
Columbus, Ohio	7	<0.1	0.1	0.1
Toledo, Ohio	5	<0.1	0.1	<0.1
Akron, Ohio	6	<0.1	0.1	0.1
Dayton, Ohio	5	<0.1	0.1	<0.1
Hamilton, Ohio	6	<0.1	0.1	0.1
Milwaukee, Wis	6	<0.1	0.1	<0.1
Madison, Wis	7	<0.1	<0.1	<0.1
Door County, Wis [1]	6	<0.1	0.1	<0.1
Des Moines, Iowa	8	<0.1	0.1	0.1
Davenport, Iowa	8	<0.1	0.1	<0.1
Clayton County, Iowa [1]	8	<0.1	0.1	0.1
Wichita, Kans	7	<0.1	0.1	0.1
Topeka, Kans	8	<0.1	0.1	0.1
Minneapolis, Minn	6	<0.1	<0.1	<0.1
Duluth, Minn	6	<0.1	<0.1	<0.1
St. Paul, Minn	7	<0.1	0.1	<0.1
Kansas City, Mo	6	<0.1	0.1	0.1
St. Louis, Mo	7	<0.1	0.1	0.1
Shannon County, Mo [1]	8	<0.1	0.1	<0.1
Omaha, Nebr	8	<0.1	0.2	0.1
Thomas County, Nebr	6	<0.1	0.1	<0.1
Bismarck, N. D	5	<0.1	0.1	<0.1
Ward County, N. D [1]	5	<0.1	<0.1	<0.1
Sioux Falls, S. D	8	<0.1	0.1	<0.1
Black Hills Forest, S. D [1]	6	<0.1	0.1	0.1
Little Rock, Ark	5	<0.1	0.1	0.1
Montgomery County, Ark [1]	6	<0.1	0.1	0.1
New Orleans, La	8	<0.1	0.1	0.1
Shreveport, La	7	<0.1	0.1	0.1
Albuquerque, N. M	7	0.1	0.1	0.1
Colfax County, N. M [1]	6	<0.1	0.1	0.1
Tulsa, Okla	8	<0.1	0.1	0.1
Oklahoma City, Okla	6	<0.1	0.1	0.1
Cherokee County Okla [1]	6	<0.1	0.1	0.1
Houston, Tex	6	<0.1	0.1	0.1
Dallas, Tex	4	<0.1	0.1	<0.1
San Antonio, Tex	6	<0.1	0.1	<0.1
Austin, Tex	6	<0.1	0.1	0.1
Beaumont, Tex	8	<0.1	0.1	0.1
Galveston, Tex	6	<0.1	0.1	0.1
Calhoun County, Tex [1]	3	<0.1	0.1	0.1
Denver, Col	7	<0.1	0.1	0.1
Montezuma County, Col [1]	6	<0.1	0.1	0.1
Boise, Idaho	7	<0.1	0.3	0.1
Butte County, Idaho [1]	6	<0.1	0.3	0.1
Helena, Mont	7	<0.1	0.1	0.1
Glacier National Park, Mont [1]	6	<0.1	0.1	<0.1
Salt Lake City, Utah	6	<0.1	0.1	0.1
Cheyenne, Wyo	7	<0.1	0.1	<0.1
Yellowstone Park, Wyo [1]	8	<0.1	0.1	<0.1
Anchorage, Alaska	6	<0.1	0.1	0.1
Pt Woronzof Alaska [1]	6	<0.1	0.1	<0.1
Phoenix, Ariz	7	0.1	0.2	0.1
Tuscon, Ariz	6	0.1	0.1	0.1
Maricopa County, Ariz [1]	6	<0.1	0.1	0.1
Grand Canyon Park, Ariz [1]	7	<0.1	0.1	0.1
Los Angeles, Calif	7	<0.1	0.2	0.1
San Francisco, Calif	6	<0.1	0.1	<0.1
Berkeley, Calif	6	<0.1	0.1	<0.1
San Jose, Calif	6	<0.1	0.2	0.1
San Diego, Calif	5	<0.1	0.1	0.1
San Bernardino, Calif	6	<0.1	0.2	0.1
Oakland, Calif	7	<0.1	0.1	<0.1
Long Beach, Calif	7	<0.1	0.1	<0.1
Glendale, Calif	6	<0.1	0.1	0.1
Humboldt County, Cal [1]	6	<0.1	<0.1	<0.1
Honolulu, Hawaii	6	<0.1	0.1	<0.1
Kahaluu, Hawaii [1]	7	<0.1	<0.1	<0.1
Las Vegas, Nev	7	<0.1	0.1	0.1
White Pine County, Nev [1]	8	<0.1	0.1	<0.1
Portland, Oreg	7	<0.1	0.1	<0.1
Eugene, Oreg	5	<0.1	<0.1	<0.1
Medford, Oreg	6	<0.1	0.2	0.1
Curry County, Oregon [1]	4	<0.1	0.1	0.1
Seattle, Wash	6	<0.1	0.1	<0.1
Spokane, Wash	6	<0.1	0.1	0.1
Clallam County, Wash [1]	4	<0.1	<0.1	<0.1

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[1] Nonurban station.

Gross Beta Radioactivity In Precipitation

National Air Sampling Network, Precipitation Collection Section, Public Health Service

During 1959 a precipitation collection and analysis program was established by the Weather Bureau Research Station in Cincinnati, Ohio, and the National Air Sampling Network. The collection stations are located at Weather Bureau offices or airport stations. Monthly composite samples of precipitation are collected at 30 stations and forwarded to the Network laboratory for analysis. A list of these precipitation collection stations is given below. Samples are analyzed for total solids and a large number of metals and nonmetals. In addition, samples representing 85 percent or more of the official rainfall recorded at the collecting stations are analyzed for fission product gross beta radioactivity if a large enough volume remains after the requirements for the chemical analysis have been met.

PRECIPITATION COLLECTION STATIONS

National Air Sampling Network

Alabama: Montgomery
California: Santa Maria
Colorado: Grand Junction
Florida: Tampa
Idaho: Pocatello
Illinois:
  Chicago (Midway Airport)
  Chicago (O'Hare Airport)
Louisiana: Lake Charles
Maine: Caribou
Maryland: Silver Hill
Massachusetts: Nantucket
Michigan: Sault Ste. Marie
Minnesota: St. Cloud
Missouri: Columbia
Montana: Glasgow
Nebraska: Grand Island
Nevada: Las Vegas
New York: Albany
North Carolina: Cape Hatteras
Ohio:
  Cincinnati (research station)
  Cincinnati (airport)
Pennsylvania: Philadelphia
South Carolina:
  Charleston
  Greenville
Tennessee: Nashville
Texas:
  Brownsville
  San Angelo
  Amarillo
Virginia: Sterling
Washington: Tatoosh Island

TABLE 1.—GROSS BETA RADIOACTIVITY OF PRECIPITATION

National Air Sampling Network, Public Health Service, First Quarter 1961

Station	January		February		March	
	μμc/liter	μμc/m²	μμc/liter	μμc/m²	μμc/liter	μμc/m²
Albany, N. Y.	([a])	([a])	([a])	([a])	18	1,300
Amarillo, Tex.	([a])	([a])	([a])	([a])	19	1,100
Cape Hatteras, N. C.	([a])	([a])	8	600	10	700
Caribou, Maine	([a])	([a])	10	900	15	1,000
Charleston, S. C.	([a])	([a])	7	700	9	1,600
Cincinnati, Ohio: (Airport)	([a])	([a])	10	900	([a])	([a])
(WBRS)	([a])	([a])	11	1,000	37	4,200
Columbia, Mo.	([a])	([a])	([a])	([a])	16	1,800
Greenville, S. C.	([a])	([a])	6	1,000	([a])	([a])
Lake Charles, La.	11	1,500	4	700	6	600
Montgomery, Ala.	8	400	2	800	10	2,700
Nantucket, Mass.	([a])	([a])	([a])	([a])	19	1,900
Nashville, Tenn.	([a])	([a])	7	900	([a])	([a])
San Angelo, Tex.	9	800	([a])	([a])	([a])	([a])
Sault Ste. Marie, Mich.	([a])	([a])	([a])	([a])	25	1,700
Sterling, Va.	([a])	([a])	13	1,300	([a])	([a])
Tampa, Fla.	([a])	([a])	6	300	([a])	([a])
Tatoosh, Wash.	([a])	([a])	6	2,900	10	2,000

[a] No data available due to low collection efficiency or inadequate sample.

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Radioactivity Measurements In Air

U.S. Naval Research Laboratory

Radioactivity measurements of air-filter samples collected at various sites near the 80th Meridian (West) are made by the U.S. Naval Research Laboratory under a program partially financed by the Atomic Energy Commission.

The daily record of fission product beta activity during February 1961 is presented in table 1, and the radioactivity profile for the same month is shown in figure 1. This figure now illustrates the data plotted in semilogarithmic coordinates. Previously the data was presented in rectangular coordinates with the abscissa expressed in disintegrations per minute per cubic meter. The concentrations in table 1 are expressed in disintegrations per minute per cubic meter of air at the collecting site (2.2 disintegrations per minute per cubic meter equals 1 micromicrocurie per cubic meter).

Figure 1.—PROFILE OF BETA ACTIVITY, AVERAGE MEASUREMENTS OF SURFACE AIR AT STATIONS NEAR THE 80th MERIDIAN (WEST), U.S. Naval Research Laboratory, (February 1961)

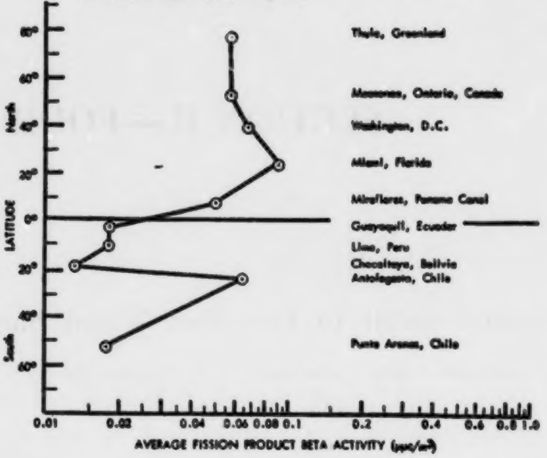

TABLE 1.—DAILY RECORD OF FISSION PRODUCT BETA ACTIVITY COLLECTED BY AIR FILTRATION

U.S. Naval Research Laboratory, February 1961

[dpm/m³]

Day	Punta Arenas, Chile	Antofagasta, Chile	Chacaltaya, Bolivia	Lima, Peru	Guayaquil, Ecuador	Miraflores, Panama Canal Zone	Mauna Loa, Hawaii	Miami, Florida	Washington D. C.	Moosonee, Canada Ontario,	Thule, Greenland
1	0.05	0.21	------	0.01	0.03	0.11	0.06	0.18	0.19	------	0.11
2	0.02	0.21	------	0.01	0.02	0.08	0.08	0.18	0.11	------	0.11
3	0.02	0.21	------	0.01	------	0.08	0.08	0.18	0.11	------	0.13
4	0.02	------	------	0.02	0.06	0.07	0.06	0.14	0.09	------	0.13
5	0.02	------	------	0.02	0.03	0.07	0.06	0.14	0.09	------	0.10
6	0.02	------	0.02	0.02	0.04	0.07	0.06	0.14	0.09	------	0.10
7	0.03	0.13	0.02	0.06	0.03	0.07	0.05	0.15	0.18	------	0.10
8	0.03	0.13	0.04	0.06	0.03	0.07	0.05	0.15	0.18	------	0.13
9	0.04	0.12	0.01	0.04	0.03	0.10	0.06	0.15	0.21	------	0.13
10	0.04	0.12	0.02	0.04	0.02	0.10	0.06	0.15	0.21	------	0.17
11	0.05	0.09	0.01	0.02	0.02	0.08	0.11	0.24	0.18	------	0.17
12	0.05	0.09	0.03	0.02	0.02	0.08	0.11	0.24	0.18	------	0.14
13	0.05	0.09	0.01	0.02	0.03	0.08	0.11	0.24	0.18	------	0.14
14	0.08	0.15	0.01	0.12	0.02	0.09	0.11	0.31	0.19	------	0.14
15	0.08	0.15	0.00	0.12	0.03	0.09	0.11	0.31	0.19	------	0.12
16	------	------	0.04	------	0.03	0.16	0.22	0.31	0.15	------	0.12
17	------	------	0.05	------	------	0.16	0.22	0.31	0.15	------	0.14
18	------	0.16	0.04	------	0.03	0.21	0.03	0.17	0.16	------	0.14
19	------	0.16	0.04	------	0.03	0.21	0.03	0.17	0.16	------	0.13
20	------	0.16	0.02	------	0.03	0.21	0.03	0.17	0.16	------	0.13
21	------	------	0.03	0.06	------	0.16	0.04	0.13	0.11	------	0.13
22	------	------	0.04	0.06	0.07	0.16	0.04	0.13	0.11	------	0.12
23	------	------	0.03	------	0.03	0.15	0.10	0.12	0.08	------	0.12
24	------	------	0.03	------	0.06	0.15	0.10	0.12	0.08	------	0.13
25	------	------	0.03	0.03	------	0.08	0.08	0.25	0.20	0.11	0.13
26	------	------	0.04	0.03	------	0.08	0.08	0.25	0.20	0.11	0.11
27	------	------	0.05	0.03	0.09	0.08	0.08	0.25	0.20	0.11	0.11
28	------	0.15	0.04	0.05	0.04	0.10	0.07	0.31	0.16	0.20	0.11
Mean value	0.04	0.14	0.03	0.04	0.04	0.11	0.08	0.20	0.15	0.13	0.13

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SECTION II.—FOOD, OTHER THAN MILK

Strontium-90 In Canadian Wheat Samples

Health and Safety Laboratory, U.S. Atomic Energy Commission

Strontinum-90 and calcium levels in wheat from a number of foreign countries, reported by the Health and Safety Laboratory were presented in *Radiological Health Data,* Volume II, Number 4. Analyses of a set of samples representing wheat grown in Canada during 1958 and 1959 have now been completed. The results of table 1[1] are seen to be of the same order of magnitude and variability as those found for United States wheat grown in the same years.

TABLE 1.—STRONTIUM-90 AND CALCIUM CONTENT OF CANADIAN WHEAT

Year	Number of samples	Calcium				Strontium-90							
		gm/kg original material				μμc/gm Ca				μμc/kg original material			
		Mean	Std. dev.	Min.	Max.	Mean	Std. dev.	Min.	Max.	Mean	Std. dev.	Min.	Max.
1958	5	0.26	0.06	0.16	0.30	85	31	39	123	24	8	11	31
1959	48	0.33	0.12	0.23	0.91	124	37	38	185	39	10	12	57

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[1] Data from *Quarterly Summary Report, HASL-111,* April 1, 1961.

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SECTION III.—MILK

Milk Monitoring Program

Division of Radiological Health, Public Health Service

There are two Public Health Service Milk Monitoring Programs. The original network consisted of five milkshed sampling stations. It was later expanded to twelve stations, nine of which are still active. Raw milk is spot sampled at these stations. During 1960 a new sampling program of 60 stations was established. Processed milk is sampled at these stations. Since the sampling procedures for the raw milk sampling stations and the processed milk area sampling stations are different, they are described and reported separately. The Public Health Service Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, continues to conduct the analyses for the original network stations; the Public Health Service Southeastern Radiological Health Laboratory at Montgomery, Ala., and the Southwestern Radiological Health Laboratory at Las Vegas, Nev., provide analytical services for the new program.

The purposes of the two sampling programs are not the same. The original network was established to develop sampling and radiochemical analytical proficiencies under conditions which would remain similar over a period of time in regard to the source of milk. During the operation of this program it became apparent that a broader sampling program, more directly related to the milk consumed by the population, was necessary. The Public Health Service and the Department of Health, Education, and Welfare acted to provide facilities for this change. This resulted in the transition from the program of sampling raw milk, collected from milksheds of limited size, to a sampling program designed to be representative of the processed milk consumed in a given municipality.

In some instances, the newly designated stations are the same as those which were reported originally. The establishment of the new processed milk area sampling stations does not preclude the need for further raw milk sampling from the selected milkshed serving the same city. It is important that both networks be in operation for a sufficient period of time to provide an overlap for the purpose of comparative study.

Because of the different sources of these samples, changes in the method of collecting samples, and the utilization of different laboratory techniques, differences were anticipated in the amounts of radioactivity found in the milk under the two programs. For this reason, an investigation to determine the comparability of the two programs was begun in January 1961. This investigation covers many factors, including laboratory methodology and collection methods. Until this study has been completed and additional experience has been gained under the new program, no valid interpretation can be made of any differences of radioactivity in milk samples collected under the two systems.

Publication of the data from each program will normally follow about four months after sample collection because of the time required for shipment, processing, decay product build-up, compilation of the data, and clearance and publication procedures.

Raw Milk Sampling Stations

The initial purpose of establishing this network was in keeping with the normal and continuing program of the Public Health Service to determine trends in our changing environment with respect to measuring the amounts of radioactivity in water, air, milk, and other foods. Milk was the food chosen for initial testing because it is among the most important components of the diet and is available at all seasons of the year and in all climates. A primary objective was to develop effective collection systems and radiochemical analysis procedures which would make them more suitable for larger scale programs.

The criteria on which the selection of the original sampling stations was based appeared in the discussion sections of all Volume I issues of *Radiological Health Data.*

One-gallon raw milk samples are collected from a dairy company once each month and forwarded by air parcel post to the Robert A. Taft Sanitary Engineering Center for radionuclide analyses. These samples represent between 2,000 and 90,000 gallon lots. The concentrations of iodine-131, barium-140, cesium-137, and naturally-occurring potassium-40 are all currently being measured by gamma scintillation spectroscopy. Total radiostrontium and strontium-90 are determined following radiochemical separations. The amount of strontium-90 is calculated by measuring the build-up of the strontium-90 daughter decay product, yttrium-90, over a two-week period. Measurements are made in a low background anticoincidence beta counter. The total radioactive strontium is counted in a shielded internal proportional counter. The difference between the total strontium-90 is reported as strontium-89. Stable calcium is also determined.

The April through September 1960 issues of *Radiological Health Data* list references for technical descriptions of the methodology of analyses used.

February 1961 data for the raw milk sampling stations are presented in table 1.

Processed Milk Sampling Stations

The new milk surveillance program will provide additional information on levels of radioactivity in milk consumed by the public. The new stations have been established in cooperation with State and local health and milk sanitation agencies. Each city has been selected to provide adequate coverage with respect to production areas and the consuming population. The emphases of this expanded sampling and radioassay program are—

1. Measuring the levels of radioactivity of the milk consumed by the public in various regions of the country by obtaining samples of pasteurized and homogenized milk at the processing plant, and
2. Providing one sampling point within each State with additional points when indicated by widely varying conditions of the milk supply or the need to provide coverage of large population groups. This differs from the original set of sampling stations whose selection was based principally upon certain criteria involving milk production and milkshed area characteristics.

The new network was designed to sample processed milk rather than the raw product. The sampling procedure was developed to provide a sample from one day's sales per month in a community which would be as representative of the total supply as can be achieved under practical conditions. Each sample is a composite of those plants supplying not less than 90 percent of a city's milk supply. The contribution from each plant to the total sample is approximately proportional to the volume of milk sold.

The samples from the new stations are collected with the assistance of the various State and local health and milk sanitation agencies and are shipped for analyses to either the Southwestern or Southeastern Radiological Health Laboratory. The Southeastern Radiological Health Laboratory processes samples from the 30 states generally east of the Mississippi, and the Southwestern Radiological Health Laboratory processes samples from the western states. Figure 1 shows the locations of these stations.

At the present time radioassays for Sr^{90}, Cs^{137}, Sr^{89}, Ba^{140}, and I^{131} are being performed. The latter three isotopes are below present limits of detection. The lower levels of detection for Sr^{89} is 5 μμc/liter, and for Ba^{140} and I^{131}, 10 μμc/liter. Other radionuclides of concern to public health agencies will be included for assay as necessary for more complete monitoring of the milk supply.

The St. George, Utah, sample is collected as part of the monitoring program around the Nevada Test Site. Because it does not fulfill the processed milk sampling criteria, it will no longer be reported as part of this surveillance program.

February 1961 data from the two laboratories are presented in table 2.

TABLE 1.—RADIOACTIVITY IN MILK—RAW MILK SAMPLING STATIONS

Public Health Service, Milk Monitoring Program, Robert A Taft Sanitary Engineering Center, February 1961

[Radioactivity concentrations in μμc/liter]

Area	Calcium (grams/liter)		Strontium-90		Cesium-137	
	February	Yearly average	February	Yearly average	February	Yearly average
Atlanta, Ga	1.17	1.14	15	14	25	30
Austin, Tex	1.12	1.11	5	4	10	10
Chicago, Ill	1.20	1.12	6	9	20	25
Cincinnati, Ohio	1.22	1.16	8	9	15	20
New York, N. Y	1.08	1.10	9	9	20	20
Sacramento, Calif	1.22	1.14	7	4	10	10
Salt Lake City, Utah.	1.15	1.12	6	6	10	20
Spokane, Wash	1.18	1.13	9	10	15	30
St. Louis, Mo	1.24	1.20	12	17	20	25

Note: I^{131} and Ba^{140} below detectable limits for all samples collected in February. These limits are 10 μμc/liter for I^{131} and Ba^{140}, and 5 μμc/liter for Sr^{89}.

FIGURE 1.—PROCESSED MILK AREA SAMPLING STATIONS

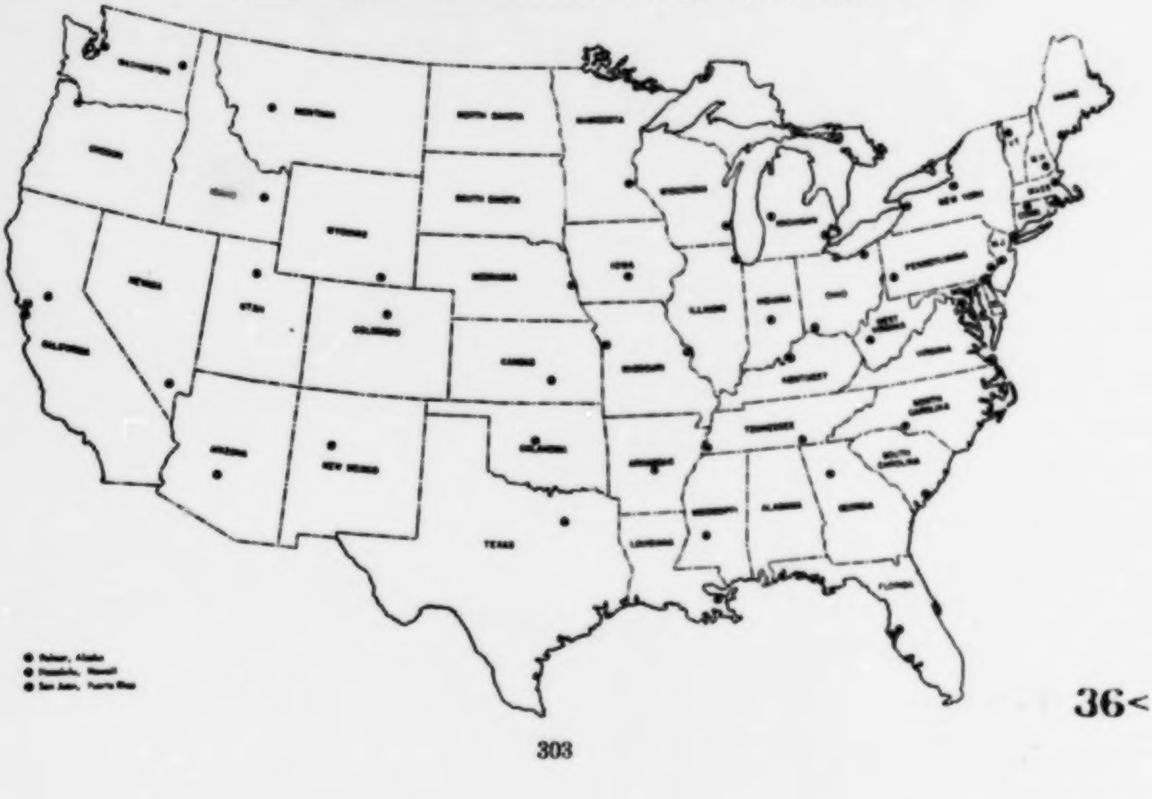

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TABLE 2.—RADIOACTIVITY IN MILK—PROCESSED MILK AREA SAMPLING STATIONS, FEBRUARY 1961

(Radioactivity concentrations in µµc/liter)

Area	Calcium (grams/liter)		Strontium-90		Cesium-137	
	February	Average to Date	February	Average to Date	February	Average to Date
Albuquerque, N. Mex.	1.08	1.10	4	4	<5	<5
Atlanta, Ga.	1.24	1.24	6	9	15	<5
Austin, Tex.	1.19	1.20	2	2	<5	<5
Baltimore, Md.	1.20	1.21	6	7	<5	<5
Boston, Mass.	1.28	1.21	10	11	<5	10
Buffalo, N. Y.	1.16	1.18	6	6	<5	<5
Burlington, Vt.	1.28	1.21	12	9	<5	10
Charleston, S. C.	1.28	1.29	8	10	10	5
Charleston, W. Va.	1.22	1.19	4	8	<5	<5
Charlotte, N. C.	1.29	1.24	5	11	<5	5
Chicago, Ill.	1.16	1.15	5	6	<5	<5
Cincinnati, Ohio	1.22	1.20	8	8	<5	<5
Cleveland, Ohio	1.16	1.17	6	7	<5	<5
Dallas, Texas	1.30	1.23	4	6	<5	<5
Denver, Colo.	0.95	1.09	6	6	<5	10
Des Moines, Iowa	1.00	1.04	6	7	5	10
Detroit, Mich.	1.20	1.17	5	7	<5	<5
Grand Radids, Mich.	1.25	1.24	8	8	<5	5
Hartford, Conn.	1.20	1.19	7	8	10	10
Helena, Mont.	1.00	1.07	4	6	5	10
Honolulu, Hawaii	1.04	1.07	4	5	<5	15
Idaho Falls, Idaho	1.07	1.07	5	5	<5	15
Indianapolis, Ind.	1.24	1.22	6	6	<5	<5
Jackson, Miss.	1.30	1.33	10	11	<5	<5
Kansas City, Mo.	1.02	1.07	6	8	<5	10
Laramie, Wyo.	1.08	1.06	5	5	<5	5
Las Vegas, Nev.	1.06	1.05	2	2	<5	<5
Little Rock, Ark.	1.34	1.23	14	13	10	<5
Louisville, Ky.	1.18	1.19	8	8	<5	<5
Manchester, N. H.	1.18	1.22	8	11	10	25
Memphis, Tenn.	1.32	1.28	8	9	<5	<5
Milwaukee, Wis.	1.20	1.18	4	6	<5	<5
Minneapolis, Minn.	0.95	1.03	8	8	5	<5
New Orleans, La.	1.25	1.26	6	12	<5	<5
New York, N. Y.	1.14	1.14	6	9	<5	5
Norfolk, Va.	1.12	1.20	6	9	<5	<5
Oklahoma City, Okla.	1.28	1.20	6	8	<5	<5
Omaha, Nebr.	1.10	1.05	5	6	10	5
Palmer, Alaska	1.10	1.08	4	7	<5	10
Philadelphia, Pa.	1.27	1.19	8	8	<5	5
Phoenix, Ariz.	1.20	1.08	1	3	<5	10
Pittsburgh, Pa.	1.28	1.22	8	11	<5	5
Portland, Me.	1.16	1.15	10	11	20	15
Portland, Oreg.	1.15	1.12	6	10	15	25
Providence, R. I.	1.25	1.22	8	11	<5	10
Sacramento, Calif.	1.08	1.06	2	4	<5	<5
Salt Lake City, Utah.	1.02	1.00	3	5	10	5
San Francisco, Calif.	1.13	1.11	2	4	<5	5
San Juan, P. R.	1.07	1.15	2	4	<5	<5
Seattle, Wash.	1.07	1.09	7	8	10	25
Spokane, Wash.	1.04	1.09	5	7	10	15
St. Louis, Mo.	1.02	1.04	6	7	15	25
Syracuse, N. Y.	1.29	1.22	6	8	<5	10
Tampa, Fla.	1.28	1.28	5	5	25	60
Trenton, N. J.	1.22	1.23	6	8	<5	<5
Washington, D. C.	1.16	1.18	6	8	<5	<5
Wichita, Kans.	1.05	1.08	5	6	<5	<5
Wilmington, Del.	1.17	1.21	6	8	<5	5

Because this program was initiated in 1960 and sampling necessarily became operative in a staggered sequence, the averages shown represent all analyses performed to date. Average will normally be for the latest 12 month period after sampling began. For the February data, the averages include five to twelv analyses.

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SECTION IV.—WATER

National Water Quality Network

Division of Water Supply and Pollution Control, Public Health Service

The National Water Quality Network was established under the provision of Section 4(c) of Public Law 660, which states "***The Surgeon General shall***collect and disseminate basic data***[relating] to water pollution and the prevention and control thereof."

This Network, operated in cooperation with State and local health agencies, was started in October 1957. At present, there are 75 sampling stations located on major waterways used for public water supply, propagation of fish and wildlife, recreational purposes, and for agricultural, industrial, and other uses. Some of these stations are on interstate, coastal, and international boundary waters, and waters on which activities of the Federal Government may have an impact. Ultimately, a total of 250 to 300 stations will be in operation. A few of the more recently established stations have not begun to report radioactivity.

Samples of water are examined for chemical, physical, and biological quality insofar as these relate to pollution. Samples for some determinations are taken weekly, others monthly, and for some continuous composite samples of 10 to 15 days are obtained.

Gross alpha and beta measurements are made on both suspended and dissolved solids in the raw surface water samples. The levels of radioactivity associated with dissolved solids provide a rough measure of levels which may be found in a treated water, where such water treatment removes substantially all of the suspended matter. Naturally occurring radioactive substances in the environment are the source of essentially all of the alpha activity. The contamination of the environment from manmade sources is the major contributor to the beta activity. It should be noted that with the cessation of weapons testing, beta activity in most raw waters is generally approaching a level attributable solely to natural beta activity. Natural beta activity can be two or three times the natural alpha activity based on the presence of the same nuclides. Some exceptions to this are seen, notably the data for the Columbia River and the Animas River.

While beta determinations for the first two years of the Network operation have been conducted on each sample weekly, the alpha determinations are reported generally on a composite sample of more than one week. Beginning with samples taken in January 1960, beta determinations were performed on composite samples obtained by combining two weekly samples. The alpha data will be reported on three-month composite samples, with one-quarter of the stations being covered each month. All the data reported in table 1 represent the average of all information available for the month indicated.

Strontium-90 data reported are the results

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS

(Average concentrations in μμc/liter)

Station	Quarter ending December 31, 1960	January 1961					
		Beta activity			Alpha activity		
	Strontium-90	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River: Cedar Hill, N. Mex.	------	29	19	48	9	19	28
Apalachicola River; Chattahoochie, Fla.	------	0	5	5	------	------	------
Arkansas River:							
Coolidge, Kans.	------	0	0	0	1	31	32
Ponca City, Okla.	------	8	0	8	0	0	0
Pendleton Ferry, Ark.	(1)	0	0	0	1	1	2
Chattahoochie River:							
Atlanta, Ga.	0.3	<1	2	2	0	0	0
Columbus, Ga.	------	0	0	0	0	0	0
Colorado River:							
Loma, Colo.	------	0	0	0	2	11	13
Page, Ariz.	0.4	4	28	32	<1	20	13
Hoover Dam, Ariz.-Nev.	------	0	4	4	0	9	9
Parker Dam, Ariz.-Calif.	1.2	0	0	0	0	12	12
Yuma, Ariz.	------	0	0	0	0	10	10
Columbia River:							
Pasco, Wash.	------	133	758	891	0	1	1
Bonneville Dam, Oreg.	0.5	66	258	324	0	1	
Clatskanie, Oreg.	------	24	142	166	------	------	------
Delaware River:							
Martin's Creek, Pa.	------	0	0	0	0	0	0
Philadelphia, Pa.	------	0	0	0	1	<1	2
Escambia River: Century, Fla.	(1)	0	0	0	1	1	2
Great Lakes:							
Gary, Ind.	------	0	0	0	0	0	0
Duluth, Minn.	------	0	1	1	0	0	0
Detroit, Mich.	------	0	1	1	0	0	0
Buffalo, N. Y.	------	1	0	1	<1	1	2
Milwaukee, Wis.	0.2	0	0	0	0	<1	<1
Hudson River: Poughkeepsie, N. Y.	0.4	0	1	1	0	0	0
Illinois River; Peoria, Ill.	0.5	0	9	9	1	3	4
Kanawha River: Winfield Dam W. Va.	0.2	0	<1	<1	------	------	------
Klamath River; Copco, Oreg.	------	0	2	2	0	<1	1
Little Miami River; Cincinnati, Ohio	(1)	0	1	1	1	1	2
Mississippi River:							
Red Wing, Minn.	------	0	4	4	0	2	2
Burlington, Iowa	------	0	0	0	1	1	2
E. St. Louis, Ill.	------	0	0	0	0	4	4
Cape Girardeau, Mo.	------	0	0	0	1	1	2
West Memphis, Ark.	1.0	0	12	12	1	1	2
Delta, La.	------	0	12	12	1	1	2
Missouri River:							
Williston, N. Dak.	------	0	2	2	0	7	7
Yankton, S. Dak.	------	0	0	0	0	5	5
Omaha, Nebr.	------	0	0	0	0	6	6
St. Joseph, Mo.	0.5	0	0	0	0	4	4
Kansas City, Kans.	------	0	4	4	0	4	4
St. Louis, Mo.	------	4	2	6	1	6	7
Ohio River:							
East Liverpool, Ohio	------	0	0	0	0	1	1
Wheeling, W. Va.	0.6	------	------	------	------	------	------
Huntington, W. Va.	0.4	0	0	0	1	1	2
Evansville, Ind.	0.8	11	0	11	2	0	2
Cairo, Ill.	------	4	0	4	0	0	0
Potomac River:							
Williamsport, Md.	------	3	0	3	0	0	0
Great Falls, Md.	------	0	0	0	0	0	0
Red River, North: Grand Forks, N. Dak.	------	0	7	7	0	4	4
Red River, South:							
Denison, Tex.	0.7	0	0	0	0	2	2
Index, Ark.	------	0	5	5	2	2	4
Alexandria, La.	------	51	2	53	10	1	11
Rio Grande River:							
Alamosa, Colo.	------	4	9	13	0	2	2
El Paso, Tex.	------	0	0	0	1	0	1
Laredo, Tex.	------	0	0	0	0	2	2
Brownsville, Tex.	------	0	0	0	------	------	------
Sabine River: Ruliff, Tex.	------	5	1	6	<1	<1	1
St. Clair River; Port Huron, Mich.	------	<1	0	<1	0	<1	<1
St. Lawrence River: Massena, N. Y.	0.6	0	<1	<1	0	1	1
St. Mary's River: Sault Ste. Marie, Mich.	------	0	1	1	0	0	0
Schuylkill River: Philadelphia, Pa.	(1)	0	0	0	0	1	1
Savannah River:							
Port Wentworth, Ga.	0.5	0	16	16	------	------	------
North Augusta, S. C.	------	0	2	2	0	0	0
Snake River:							
Wawawai, Wash.	------	0	0	0	0	3	3
Weiser, Idaho	0.2	1	12	13	0	4	4
Susquehanna River:							
Sayre, Pa.	------	1	<1	1	0	<1	<1
Conowingo, Md.	0.4	0	0	0	0	<1	1
Tennessee River:							
Chattanooga, Tenn.	0.9	2	125	127	0	2	2
Bridgeport, Ala.	------	0	68	68	0	0	0
Yellowstone River; Sidney, Mont.	------	0	0	0	0	20	20

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[1] Insufficient sample for analysis.

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of determinations on composite samples for a three-month period ending in the month shown.

Additional information and data may be obtained from the following sources:

National Water Quality Network Annual Compilation of Data, PHS Publication. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Price $1.50.

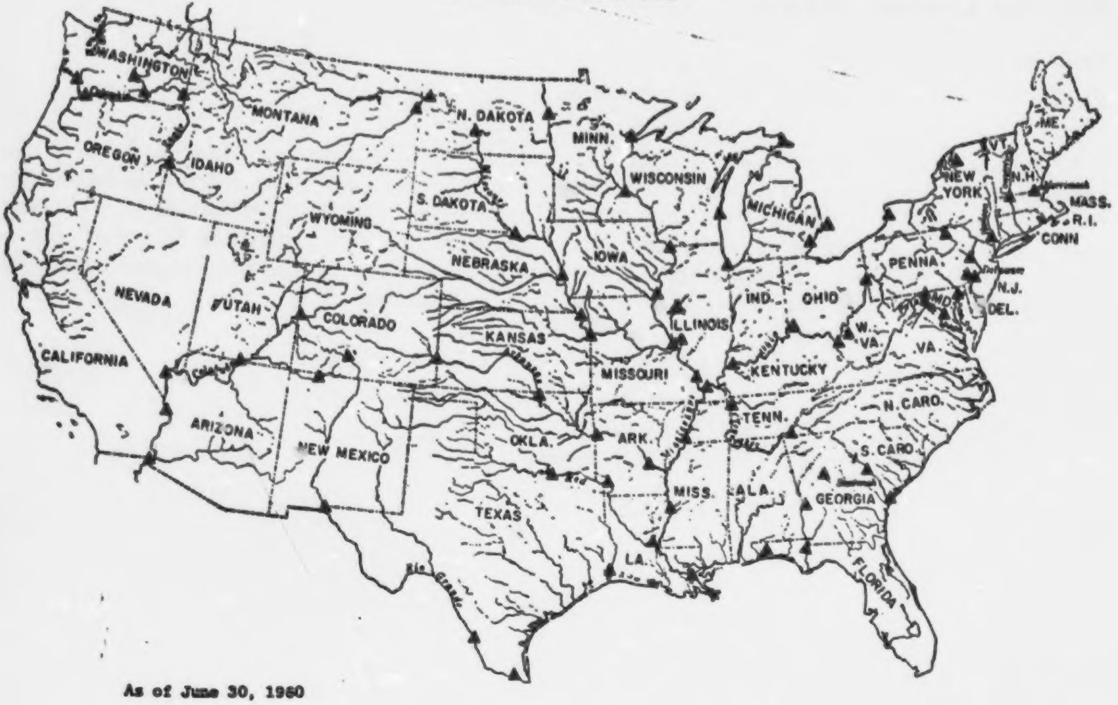
Report on National Water Quality Control Network, submitted by Dr. F. J. Weber, Chief, Division of Radiological Health, PHS, at the Joint Committee on Atomic Energy Hearings on Fallout from Nuclear Weapons Tests, Vol. 1, May 1959, pages 167-169.

Setter, L. R., Regnier, J. E., and Diephaus, A. "Radioactivity of Surface waters in the United States," Jour. AWWA *51*, 1377 (1955).

Straub, C. P., Setter, L. R., Goldin, S., and Hallbach, P. F., "Strontium-90 in Surface Waters," Jour. AWWA *52*, 756 (1956).

Setter, L. R., and Baker, S. L., "Radioactivity of Surface Waters in the United States," *Radiological Health Data*, Volume I, No. 7 (1960).

FIGURE 1—PUBLIC HEALTH SERVICE NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS



As of June 30, 1960

SECTION V.—OTHER DATA

External Gamma Activity

Radiation Surveillance Network,

Division of Radiological Health, Public Health Service

Portable survey instruments are available at stations of the Radiation Surveillance Network for recording levels of external gamma radiation. Measurements are made daily approximately three feet above the ground. These readings are not precise but are sufficiently accurate to illustrate any significant variations above background. The differences among the values shown in the following table are within the variance anticipated due to differences in normal background and in instrument response characteristics.

TABLE 1.—EXTERNAL GAMMA ACTIVITY, FEBRUARY 1961

Radiation Surveillance Network, Public Health dervice

Station location	Average (mr/hr)	Station location	Average (mr/hr)	Station location	Average (mr/hr)
Anchorage, Alaska	0.01	Indianapolis, Ind	0.01	Oklahoma City, Okla	0.01
Fairbanks, Alaska	(1)	Iowa City, Iowa	0.02	Ponca City, Okla	0.04
Juneau, Alaska	0.01	Topeka, Kan	0.02	Portland, Oreg	0.02
Phoenix, Ariz	0.02	New Orleans, La	0.01	Harrisburg, Pa	0.01
Little Rock, Ark	0.02	Baltimore, Md	0.02	Providence, R. I	0.02
Berkeley, Calif	0.01	Lawrence, Mass	0.02	Columbia, S. C	0.02
Los Angeles, Calif	(1)	Lansing, Mich	0.02	Edgemont, S. Dak	Inactivated
Denver, Colo	0.02	Minneapolis, Minn	0.01	Pierre, S. Dak	0.02
Hartford, Conn	0.01	Pascagoula, Miss	(1)	Austin, Tex	0.01
District of Columbia	0.02	Jefferson City, Mo	0.01	El Paso, Tex	0.02
Jacksonville, Fla	0.02	Helena, Mont	0.03	Salt Lake City, Utah	0.02
Atlanta, Ga	(1(	Trenton, N. J	(1)	Richmond, Va	0.01
Honolulu, Hawaii	0.02	Santa Fe, N. M	0.04	Seattle, Wash	0.02
Boise, Idaho	0.01	Albany, N. Y	0.02	Madison, Wis	0.01
Springfield, Ill	(1)	Gastonia, N. C	0.02	Cheyenne, Wyo	0.02

[1] No Data Received.

Cesium-137 Levels In Humans

Walter Reed Army Institute of Research, Washington, D.C. and

U.S. Army Medical Research Unit, Landstuhl, Germany

Despite the cessation of nuclear weapons testing in the fall of 1958, the United States Army Medical Service has maintained a surveillance of the fission product contamination in the human population. Two whole body counting facilities at the Walter Reed Army

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Medical Center, Washington, D.C. and the Medical Research Unit, Landstuhl, Germany have been measuring the levels of cesium-137 in people. A description of each facility and previous data were summarized in *Radiological Health Data*, Volume II, Number 4.

This report presents the results from Germany for the period December 1960 through February 1961 and from Walter Reed for the first quarter of 1961. The Landstuhl data area listed by month in table 1. The Walter Reed data are listed by geographic area in tables 2 and 3.

TABLE 1.—ASSAYS PERFORMED AT THE U. S. ARMY MEDICAL RESEARCH UNIT, LANDSTUHL, GERMANY

Date	Subjects residing in—	Number of subjects	$\mu\mu c$ Cs^{137}/gm K (average)
December 1960	West Germany	75	54
January 1961	do	165	54
February 1961	do	107	48

TABLE 2.—ASSAYS PERFORMED AT THE WALTER REED ARMY INSTITUTE OF RESEARCH, FIRST QUARTER 1961

Geographic area	Number of subjects	$\mu\mu c$ Cs^{137}/gmzK (average)
Africa	1	35
Antarctica	1	50
Caribbean	4	37
Central America	1	27
Europe	32	52
Far East	28	30
Near East	2	49
Pacific Islands	1	26
United States	170	31

TABLE 3.—ASSAYS OF INDIVIDUALS RESIDING WITHIN THE UNITED STATES PERFORMED AT THE WALTER REED ARMY INSTITUTE OF RESEARCH, FIRST QUARTER 1961

State	Number of subjects	$\mu\mu c$ Cs^{137}/gm K (average)
Alabama	2	24
Alaska	3	27
Arizona	1	18
California	8	23
Colorado	2	36
Connecticut	1	54
District of Columbia	11	32
Florida	2	35
Georgia	6	30
Hawaii	1	26
Illinois	4	27
Indiana	3	37
Iowa	3	33
Kansas	2	26
Kentucky	8	26
Louisiana	1	24
Maryland	8	28
Massachusetts	7	51
Michigan	7	25
Minnesota	7	21
Mississippi	2	24
Missouri	7	17
Nebraska	1	39
North Carolina	7	36
North Dakota	1	37
New Jersey	3	30
New York	13	36
Ohio	8	17
Oklahoma	4	32
Oregon	1	33
Pennsylvania	13	30
Rhode Island	1	35
South Carolina	1	15
Texas	6	29
Utah	1	37
Vermont	1	40
Virginia	13	32
Washington	2	40
West Virginia	3	27
Wisconsin	1	28

TABLE 4.—SUMMARY OF TABLES 1 AND 2—FIRST QUARTER 1961

Geographic area	Number of subjects	$\mu\mu c$ Cs^{137}/gm K (average)	Percent MPC [1]
Africa	1	35	0.18
Antarctica	1	50	0.25
Caribbean	4	37	0.19
Central America	1	28	0.14
Europe	32	52	0.26
Far East	28	30	0.15
Near East	2	49	0.25
Pacific Island	1	26	0.13
West Germany	347	[2] 52	0.26
United States	170	31	0.16

[1] See *Radiological Health Data*, Volume II, Number 4, pages 193 and 194.

[2] Values represent determinations for December 1960 through February 1961.

Medical Survey of Rongelap People, Five and Six Years After Exposure To Fallout[1]

U.S. Atomic Energy Commission

Following the accidental exposure to fallout radiation of inhabitants of Rongelap Atoll in the Marshall Islands in March 1954, medical surveys of the Rongelap people have been made annually under the direction of the Brookhaven National Laboratory. The summary and conclusions of the report of the survey conducted five and six years after exposure follow. Several other agencies and organizations provided assistance in conducting the surveys, namely:

The Department of Public Health, Trust Territory of the Pacific Islands; Walter Reed Army Medical Center; South Nassau Communities Hospital, New York; Atomic Bomb Casualty Commission, Japan; Anderson Hospital, University of Texas; National Institutes of Health, Public Health Service; Naval Medical Research Institute; Memorial Hospital for Cancer and Allied Diseases, New York.

A list of previous reports is shown following the summary.

"*Summary and Conclusions*"

"Continuing annual medical surveys of the people of Rongelap Island were carried out in March 1959 and March 1960, 5 and 6 years after their accidental exposure to fallout. During the 1959 survey 76 exposed persons, including their children, and 166 unexposed Rongelap people, who served as a comparison population, were examined. In addition, groups of children at Utirik, Majuro, and Kwajalein Atolls were examined as controls for the growth and development studies on the exposed Rongelap children. The 1960 survey was brief, only the exposed people being examined.

"As a result of their exposure in 1954, many of the Rongelap people had experienced early symptoms related to the gastrointestinal tract and skin. Later they developed a significant depression of their peripheral blood elements commensurate with the calculated dose of gamma radiation (175 r to 64 people and 69 r to 18 people), and beta burns of the skin along with spotty epilation. In addition, radiochemical analyses of urine samples showed that they acquired a low level body burden of radionuclides. Certain other findings were possibly related to their radiation exposure, such as loss in weight of several pounds in most of the people during the first several months after exposure and suggestive evidence of slight lag in growth and development of the children based on studies of height, weight, and bone development (but inconclusive pending verification of exact ages of some of the children).

"In spite of the depression of hemopoiesis, no signs of radiation illness developed in the people related to such depressions, and no deaths occurred that could be related to their radiation exposure. No specific therapy was given. Recovery of the peripheral blood elements, particularly lymphocytes and platelets, was very slow over the ensuing years. The beta burns, which appeared about 2 weeks after exposure, were, for the most part, superficial in nature and healed in several weeks, with only a few lesions showing later persisting changes. Specific therapy was not necessary in most cases. The hair regrew normally, beginning at 3 months after exposure. The internally absorbed radionuclides caused no known acute effects and were excreted remarkably fast with barely detectable activity being found a year or two later. On return of the people to Rongelap Island the very low levels of radioactive contamination remaining there resulted in a rise in their body burdens of cesium-137, zinc-65, and strontium-90.

"The 5- and 6-year post-exposure surveys were aimed primarily at evaluating the general medical status of the people in relation to that of the unexposed comparison population, particularly in regard to any possible late developing effects of their exposure, their hematological status, and the influence of the slightly

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[1] "Medical Survey of Rongelap People Five and Six Years After Exposure to Fallout" AEC report BNL-609 (T-179), September 1960. Available from the Office of Technical Services (OTS), U.S. Department of Commerce, Washington 25, D.C., $2.00.

contaminated environment on the assimilation, excretion, and body burden of radionuclides.

"*Medical histories* of the intervals between the examinations in 1959 and 1960 were, for the most part, uneventful and revealed no major epidemics of disease. Several deaths had occurred and new births were reported. In the exposed group, two deaths occurred and in the unexposed group, three. Two of the latter were due to influenza acquired during an epidemic on Kwajalein.

"The four deaths that have occurred in the exposed people since exposure represent a mortality rate of 8.1 per 1000 population, compared with 8.3 for the comparison population and 6.8 for the Marshall Islands as a whole. A review of the birth rate of the exposed group over the past 6 years seems to indicate no noticeable effect of their exposure on fertility. The 24 births represent a rate of 48 per 1000 population, compared with 37.3 for the Marshall Islands (1957). The 20 births over a 3-year period for the comparison population represent a rate of 62 per 1000 population. A somewhat greater incidence of miscarriages and stillbirths has been noted in the exposed women, but because of the paucity of vital statistics on the Marshallese and the small number of people involved, the data are not readily amendable to statistical analysis.

"*Physical examinations* showed the exposed and the unexposed people to be generally in a state of good health. No diseases were noted that could be directly related to radiation effects. The incidence of various disorders in both adults and children was about the same in the exposed and unexposed groups.

"In connection with growth and development studies, a project on the verification of accuracy of ages of the children has not been completed and, therefore, the suggestive evidence previously presented of possible lag in statural growth in the exposed children must await confirmation. It was noted, however, that in the 6-year chronological age group, three boys and one girl out of five boys and two girls in the exposed group exhibited significantly retarded skeletal maturation as judged by x-ray examination. The birth dates of these children seemed to be fairly well established.

"*A cardiovascular survey* of the adults showed no outstanding differences between the exposed and unexposed groups. The people appeared to have less hypertension on the whole than is noted in people in the continental United States.

"*An arthritis survey* showed no great differences between the exposed and the unexposed people, and about the same incidence as is seen in American populations.

"*An ophthalmological survey* showed no remarkable differences between the exposed and unexposed groups except possibly a slightly greater number of cases of pterygii, pingueculae, and corneal scars in the exposed group. It is not known whether this finding is of any significance in relation to their radiation exposure. Slit-lamp observations showed no opacities of the lens characteristic of radiation exposure. As a whole, visual and accommodation levels in the Marshallese appeared to be above the average in the U. S. population.

"*A dental survey* showed no significant differences in either caries rate or incidence of peridontal disease between exposed and unexposed groups. The poor oral hygiene generally observed in the Marshallese had its usual results, namely, high caries rate in teenage children, severe peridontal lesions in adults (heavy calculus and loss of alveolar bone), and edentulous mouths in the aged. Radiation exposure did not appear to have effected developing dentition in the exposed children.

"*Late effects of radiation.* Various parameters usually associated with aging were measured or estimated on a 0 to 4+ scale (skin looseness, elasticity, and senile changes; greying of the hair and balding; accomodation, visual acuity, and arcus senilis; hearing; cardiovascular changes including blood pressure and degrees of peripheral and retinal arteriosclerosis; neuromuscular function; and hand strength). Comparison of these measurements in exposed and unexposed individuals of the same age groups showed no apparent differences. A biological age score was calculated for individuals and groups by use of an average percentage score. Life shortening effects of radiation have not been apparent. As noted, the mortality rate was about the same in the exposed as in the unexposed people.

"The one case of cancer that developed in the exposed group occurred at 5 years after exposure, too soon, it is believed, to bear any

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particular relation to radiation exposure. Leukemia surveys including physical findings, studies of white cell counts and types, alkaline phosphatase staining, and basophil counts of 4000 white cells showed no evidence of leukemia or leukemic tendency. One child in the irradiated group had 3% basophils but no other positive findings. The cardiovascular and arthritis surveys, as well as the general results of the physical examinations, have not shown any apparent increased incidence of degenerative diseases in the exposed people. No radiation-induced cataracts have been observed in any of the exposed people.

"*Genetic effects* have not been specifically studied because of the small number of people involved. No apparent radiation-induced genetic changes have been detected on routine physical examination in the first-generation children of exposed parents.

"*Hematological surveys* again showed considerable fluctuation in the year-to-year mean level of leukocytes in both the exposed and unexposed groups. The mean leukocyte level of the exposed group showed a marked decrease at the time of the 1960 survey (no unexposed people were examined). The reasons for these fluctuations are not apparent. At 5 years post exposure, exposed people still had mean platelet levels 10 to 15% below those of the unexposed group. However, lymphocyte levels appeared for the first time to equal those of the unexposed group. Mean erythrocyte levels were also slightly lower in the exposed people. These blood elements in the Ailingnae group also showed some slight depression below the unexposed levels but not quite so marked as seen in the Rongelap exposed group. A general anemic tendency was noted in all the Marshallese, both exposed and unexposed. Price-Jones curves, on the average, showed a slight microcytic tendency. Serum iron levels were generally normal. The fact that some of the blood elements in the exposed group have not yet returned to the levels in the unexposed group raises the possibility that a residual radiation effect on the bone marrow persists, but other, not immediately apparent, factors may be involved.

"*Studies of genetically inherited characteristics.* Blood grouping studies in the Marshallese showed a relatively high B gene frequency, a high N gene frequency, an extremely high R^1 gene frequency, and total absence of Kell and Diego factors. These characteristics differ from those of Polynesians and suggest relationship with Southeast Asians and Indonesians. Haptoglomin studies showed the frequency of the Hp^1 gene to be higher than in European populations thus far tested and consistent with populations living near the equator. The distribution of haptoglobin types showed the population to be relatively homogeneous. Transferrins in all sera were type CC, the common European type. ß-Aminoisobutyric acid urinary levels showed the Marshallese to be the highest excretors of acid of any population thus far reported. Levels in the exposed group were about the same as in the unexposed group, and no correlation was found with body burden levels of radionuclides; this indicates that there is probably no correlation with radiation exposure. Glucose-6-phosphate dehydrogenase of the red cells appeared to be deficient in the Marshallese. Considerable caution must be exercised in evaluating the results of these studies on genetically inherited characteristics because of the small number of samples tested. The data do seem to indicate relative homogeneity of the population and closest kinship with people of Southeast Asia. These data also may be useful as a base line should genetic changes appear in later generations, possibly related to radiation exposure.

"Results of other laboratory studies carried out during the 5-year survey included the following: Serum protein levels, as has been noted before, were generally on the high side of normal; the reason for this is not apparent. Complement fixation studies for parainfluenza 1, 2, and 3, respiratory syncitial, psittacosis, and Q fever showed antibodies to all groups of viruses except that for Asian influenza, which probably had not yet seriously involved the people of the Marshall Islands. The antibody titers appeared to be somewhat lower in the exposed people. Sodium levels in the urine and food indicated about the same consumption of NaCl as in Americans. The generally lower incidence of hypertension in the Marshallese might be related to the fact that the former native diet was probably lower in salt content than the present, more westernized diet. It will be interesting to see whether the incidence

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of hypertension will later increase. Repeat studies of protein-bound iodine, total iodine, and butanol-extractable iodine of the sera showed levels lower than previously reported, and the previous higher readings are thought to be in error because of contaminated glassware, although some readings were still somewhat high. Four cases of glucosuria associated with elevated blood sugar were found in the unexposed population, which indicated a rather high incidence of diabetes. Serum assay for vitamin B_{12} showed generally high levels; the explanation was not apparent.

"*Radionuclide body burden evaluation* in the Marshallese people has been complicated by several things. The people were evacuated from their island soon after the accident and did not return until 3 years later. During the 5 years since the contaminating event, additional weapons tests held in the area have contributed to the fission products in the environment. Finally, since the diet includes a variety of imported foods, the people are not living in a "closed" environment, and therefore may not be rapidly approaching equilibrium with the environmental fission products, as might be expected under other circumstances.

"Body burdens of gamma-emitting fission products (such as Cs^{137} and Zn^{65}) were measured in a whole-body counter and checked by radiochemical analysis of urine specimens. Body burdens of Sr^{90} were estimated from urinary excretion as determined by radiochemical analyses. Both the external dose measurements on Rongelap Island and the levels of radioactive isotopes in the food on the island indicated that some increase in Cs^{137}, Zn^{65}, and Sr^{90} body burdens was to be expected when the people returned there in 1957. The Cs^{137} body burden in 1958 was about 0.68 μc about 60 times as great as in 1957, and the urinary Cs^{137} level rose by a factor of 140; the mean body burden for 1959 was 0.57μc. The mean body burden of Zn^{65} estimated from whole-body counting data was, in 1958, after the return to Rongelap, 0.36μc, 8 times as high as in 1957, and 0.44 μc in 1959. Thus, whereas the Cs^{137} levels appear to have reached a maximum and actually to have dropped in 1959, the Zn^{65} levels have shown a continued increase which is probably related to the long biological half-life of the latter. The Sr^{90} level in 1958 estimated from excretion data was 2mμc, about 20 times as high as in 1957 before the return to Rongelap. The estimated body burden in 1959 increased to 6.0 mμc, about 20% of the estimated ultimate equilibrium value. Little of the body burden of the exposed group is apparently due to their initial exposure, since at present there is little difference between the levels of the exposed and unexposed populations living on Rongelap Island. When these three isotopes have reached their estimated equilibrium values, the body burdens will still be of small significance in terms of radiation hazard.

"This study of the internal contamination of the Marshallese has provided information (1) on the movement of Cs^{137}, Zn^{65}, and Sr^{90} from the environment to man; (2) on the rate of equilibration of these isotopes with the environment; and (3) on the discrimination factors between food and man."

Reports on Previous Surveys

(1.) E. P. Cronkite, V. P. Bond and C. L. Dunham, ed., "Some Effects of Ionizing Radiation on Human Beings," AEC report TID-5358, U. S. Government Printing Office, July 1956. ($1.50)

(2.) E. P. Cronkite, et al, "Twelve-Month Post-Exposure Survey on Marshallese Exposed to Fallout Radiation," AEC report BNL-384 (T-71), August 1955. (Office of Technical Services, Department of Commerce $0.15)

(3.) R. A. Conard, et al, "Medical Survey of Marshallese Two Years After Exposure to Fallout Radiation," AEC report BNL-412 (T-80), March 1956. (OTS $0.20).

(4.) R. A. Conard, et al, "March 1957 Medical Survey of Rongelap and Utirik People Three Years After Exposure to Radioactive Fallout," AEC report BNL-501 (T-119), June 1958. (OTS $1.00).

(5.) R. A. Conard, et al, "Medical Survey of Rongelap People, March 1958; Four Years After Exposure to Fallout," AEC report BNL-534 (T-135), May 1959. (OTS $1.25).

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RADIOLOGY IN THE UNITED STATES

Recently the American College of Radiology made available to its members "A Supplementary Report to 'The Practice of Radiology in the United States—Facts and Figures'." This was based upon a nation-wide survey of hospitals and radiologists by Doctors S. W. Donaldson and Carroll J. La Vielle to assess the use of x-rays, principally for diagnostic purposes. In 1951 Dr. S. W. Donaldson published his original paper, "The Practice of Radiology in the United States—Facts and Figures." This article has been the basis for a number of estimates of radiation exposures of the population since that time. In recent years data have been assembled and published relating to the number of x-ray examinations and exposures in a few scattered portions of the United States. However, there has been no nation-wide survey conducted to assemble such information, except for the continuing work by Donaldson and La Vielle in this field of interest.

The Division of Radiological Health has received permission from the American College of Radiology and, prior to his recent death, from Dr. Donaldson, to reproduce this supplementary report. We believe the basic information contained in this report, added to the other studies being conducted, will be useful in the long-term estimation of radiation exposures of the population.

A Supplementary Report To "The Practice of Radiology In The United States—Facts and Figures"

S. W. Donaldson, M.D. and Carroll J. La Vielle, M.D.—Ann Arbor, Michigan

"WHEN changes are occurring rapidly in industry, business or the practice of any profession it should be obvious that a periodic inventory must be made in order to keep abreast of the times. Approximately eight years ago information and statistical material was collected for preparation of a paper entitled "The Practice of Radiology in the United States—Facts and Figures." The reprints of the paper have had wide distribution. It was, at that time, an effort to assay the various financial and institutional aspects of the practice of a medical specialty. As stated in the body of the original paper the study was an outgrowth of a demand from recent trainees, seeking a location or position, for information pertaining to the distribution of radiologists and the opportunities available for entering into the practice of their specialty.

"The gathering of necessary information for proper functioning of the Professional Bureau has continued and through various spot checks and direct communications with well established radiologists who have found it necessary to take on assistants, it appears that the volume of patients seen in both private offices and institutional departments has doubled every eight years for the past twenty-four, following the nation-wide financial stress of the 1930's. The greatest upsurge in the utilization of diagnostic roentgenology came immediately following World War II, when those physicians who had not had the advantage of full time radiologic consultation were able to obtain it while in the service and demanded it from civilian radiologists when they returned to private practice. In 1951 it was stated that it was safe to assume that more radiological services were being rendered to the 42,000 persons population per radiologist than had been rendered to the 122,000 per radiologist in 1931. At an April 1958 U.S. Senate hearing the ratio of physicians to population was accepted at 1:750. Therefore, 1 radiologist to each 36 physicians would be approximately 1 radiologist to 27,000 population.

"A warning of this increase in the use of diagnostic x-ray and the subsequent requirements of more space and a greater investment in equipment and a need for more trained personnel was given in 1951, but the advice was not universally heeded. In an effort to provide aid to those institutions planning additional hospital beds and to those communities contemplating building a hospital, the American College of Radiology compiled and pub-

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lished a "Planning Guide for Radiologic Installations," which has had a wide distribution. At the present time one is unable to predict whether or not the utilization of radiology for diagnosis and treatment is nearing a peak in volume of patients. If so, will future progress be confined to a refinement of methods of procedure in order to decrease the radiation exposure per individual or will new methods cause a greater usage of x-ray than is now foreseeable.

"At the beginning of the year 1958 there were in active practice in private offices and hospitals an estimated 4,500 radiologists who had been certified by the American Board of Radiology. In addition it was estimated that 600 more men were in training and assisting in rendering radiological services. Practically all qualified radiologists are now devoting full time to the specialty, although 849 physicians are listed in the 1956 American Medical Association Directory as maintaining a practice in which radiology receives special attention. The increase in the number of certified radiologists has more than kept pace with the growth in population and the increase in medical practitioners. In 1950 the statistics showed one (1) radiologist to every fifty-seven (57) physicians as a national average. The present figures compiled from the 1956 American Medical Association Directory reveal 1 certified radiologist for every 36 physicians, that is, general practitioners and specialists who are rendering medical service to the general public. In the 1951 survey the number of practicing radiologists was not deducted from the total of general practitioners, specialists and those interested in a specialty as in some communities the practicing radiologists had many self referrals. In our new compilation of figures the number of radiologists in a state was subtracted from the total number of practicing physicians and the difference then divided by the number of radiologists in order to obtain the number of practicing physicians per radiologist.

"The most notable shifts in medical population have been from general practitioners to specialists and a definite loss in the number listed as 'special attention to a specialty.' The increase in the number of radiologists per 1,000 population since the 1950 census has been greater than in any previous period of the same number of years. According to United States Government census figures the center of population is constantly shifting westward. The tabulations of distribution of physicians by specialty and by states as shown in the 1956 American Medical Association Directory show a greater percentage increase in radiologists in the West than in the East with the greatest concentration in the state of California. The following table illustrates the increases and changes in the distribution of radiologists and physicians East and West of the Mississippi River.

SUMMARY OF DISTRIBUTION OF PHYSICIANS AND RADIOLOGISTS

		Radiologists			Physicians				
		Full spec.	Att. to spec.	Total	Gen. pract.	Full spec.	Physicians / Radiologists	Att. to spec.	Total
195	East	1,853	328	2,181	49,937	38,858	(57)	16,377	105,172
	West	788	101	889	22,613	15,933	(57)	6,662	45,208
1956	East-	2,661	226	2,887	44,610	46,590	(36)	14,192	105,392
	West	1,279	54	1,333	20,106	20,524	(34)	6,283	46,913

"The number of hospital beds in this country has definitely increased in the last decade and many communities without hospitals ten years ago now have facilities of varying size depending upon the money raising ability of the community. In such areas radiologists have become established either upon a full or part time basis. In addition to the general public, radiology has expanded in the governmental institutions, local, state and federal so that those radiologists rendering radiological service in the armed service and the Veterans Administration must be considered as a factor in the health and medical problems of the general population as the shift from civilian practitioners to government medical personnel and back to civilian physicians is constantly occurring for some segment of the population. However, the socio-economic problem of the majority of radiologists is connected with the hospital and private office care of the general public. Occasional spot checks during the past several years have shown that the same general pattern has remained but with some variations from the report of 1951. The ratio of examinations to patients has increased slightly from 1.25 examinations per radiographic patient to 1.33 per patient. The number of patients having one or more diagnostic x-ray procedures after admission to a general hospital has increased from the average of 42% to 47%. Previously it had been considered that 20% of all procedures done by a radiologist were for therapy or were treatments. Our recent survey which includes approximately 500,000 patients shows that less than 15% of the procedures on these patients were therapy treatments. In order to obtain a cross section viewpoint questionnaires were sent to radiologists in a number of states and replies received from Massachusetts, Pennsylvania, Indiana, Illinois, Michigan, New York, Florida, Tennessee, California, Oklahoma, Minnesota and New Jersey. Two large teaching centers and three private offices were included.

"Fewer radiologists are in solo practice today than there were a few years ago. Even though there are still circuit riders covering several small hospitals and many hospitals in fringe areas of large cities receive part time service the major portion of hospital radiology is practiced in the larger institutions by two or more radiologists.

"A finding in the information furnished to the Professional Bureau by those institutions seeking a radiologist has been that the ratio between in-patient and out-patient examinations has shown an increase in out-patients in the midwest, western and southern parts of the country. This has been evident in that the number of examinations per department each year has been far in excess of the number of examinations expected for a hospital of a given bed capacity. Until a few years ago it was assumed that the in-patient and out-patient radiographic patients were about equal in number or the excess was generally in-patients but our latest investigation shows that the out-patient radiographic studies in most institutions now constitute a majority. All of these factors point out that smaller communities and fewer referring physicians are now able to support a radiologist.

"The formula presented in the previous paper that the personnel requirements for efficient functioning of a department of radiology were 5.6 patients per person personnel per day now appears to be 5.3. There has been an increase in paper work due to an increase in the number of subscribers to prepayment insurance plans. Microfilming and increased numbers of special examinations which monopolize rooms and technicians, more films per examination and other things not mentioned, require additional clerical and technical personnel. Film consumption has risen from approximately 2.5 films per examination to 3 and equipment value has practically doubled as new equipment for more specialized examinations is now required.

"The revenue per examination has increased within the past few years but is not uniform throughout the nation as the fees vary from the high in metropolitan areas to the low in low income communities. As a whole the fees for the various diagnostic procedures are relatively uniform and except for the isolated instances mentioned, generally fall in the median fee category. The average income per in-patient varies greatly according to the in-patient census of Blue Cross-Blue Shield subscribers and whether or not radiology is a benefit under Blue Cross. Some areas throughout the country have a high percentage of prepayment insurance plan subscriber admissions while hospitals in other communities have comparatively few. We have been unable to obtain a sufficient number of accurate statistics to enable us to predict the anticipated revenue to the Department of Radiology from each hospital bed per year. However, we have been able to show that the average revenue from each diagnostic in-patient is greater than the average revenue from the diagnostic out-patients. The total revenue per radiographic patient (in-patient and out-patient combined) will at the present time probably average

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$15.00 or slightly less in those areas with a median fee schedule.

"Even with the increase in personnel, the increase in film consumption and other items of expense, the ratio of salaries to film and chemical cost remains the same. The ratio is 3 to 2 or, that is, it takes $33.00 in salaries (exclusive of medical personnel) to use $22.00 cost in films, chemicals and contrast media, as well as other expendable supplies.

"A noticeable shift in type of radiographic examinations has been in the Genito-Urinary field. The recent survey shows a wide variation in the different departments in the frequency of requests for intravenous pyelograms in comparison with requests for a retrograde examination. Some show as many as fifty intravenous examinations to one retrograde but the overall average is four to one.

"The figures for chest examinations and gastro-intestinal studies remain practically the same or approximately one-third of all radiographic examinations are procedures involving the chest and one-half of all radiographic examinations are made up of the chests and gastro-intestinal studies including the gall bladder. Previous to this supplementary paper it had been determined that 10% of all patients admitted to a general hospital have an x-ray examination of the gastro-intestinal tract and that 10% of all patients examined in a Department of Radiology have an examination of the stomach. This means that more than 10% of all diagnostic patients have an examination by fluoroscopy. Of each 30 gastro-intestinal examination patients 18 are over 45 years of age and 12 below 45. Except for progress or follow-up examinations very few requests are received in the larger departments for an examination of the stomach, colon or gall bladder alone and this shift from a single anatomical part examination to a study of the complete gastro-intestinal tract including the gall bladder has occurred within the past ten years.

"In the previous study from information collected in 1949 and 1950 it was determined that the average radiologist rendered consultation service for 20 patients per day. This average has now apparently increased and the information is based on figures given in the recent survey and from correspondence to the Professional Bureau requesting an assistant or associate. An increase of four patients a day per radiologist from 1950 to 1958 would place the average at 7,000 patients per year and deducting 15% for therapy or treatments would leave 5,950 radiographic patients, with 1.3 examinations per patient, who would account for 7,735 examinations per radiologist per year. The 1956 Directory of the American Medical Association shows 4,220 radiologists, full and part time and since that directory was published the American Board of Radiology has certified between 450 and 500 recent trainees who combined with some non-certified radiologists will raise the figure (with allowance for deaths and retirement) to almost 5,000 active practicing radiologists. Since its beginning the American Board of Radiology has certified 5,117 radiologists. In addition there are 200-300 third and fourth year residents who perform patient services equaling some radiologists. The 5,300 clinical radiologists rendering service for an average of as many as 7,000 radiographic examinations per year would make a total of 37,100,000 radiographic examinations by radiologists and their assistants per year. This number of examinations using an average of 3 films per examination would account for 111,300,000 films or exposures per year. If one desires to carry the radiation exposures further, then it is estimated that 20,000,000 radiographic examinations are made by non-radiologists and 11,000,000 by lay laboratories, chiropractors and osteopaths. Dentists account for 180,000,000 dental films or an equal number of dental exposures.

"As a matter of substantiation of the mathematical calculations the 1956 Directory of the American Medical Association shows that 347 non-federal and Veterans Administration hospitals and 16 Federal hospitals, namely one U.S. Air Force, four U.S. Army, six Navy, four U.S. Public Health Service and one Department of Health, Education and Welfare, are approved for residency or Fellowship training in Radiology. The Federal operated hospitals reported 749,944 x-ray examinations and these combined with the 11,079,987 examinations reported by the non-federal and V. A. hospitals give a grand total of 11,829,931 x-ray examinations in the 363 residency approved departments. The number of deep x-ray therapy treatments was 1,663,427 while superficial treatments and radium treatments were reported as 144,428 and 53,121 respectively. The treatments reported under the heading of radium probably represent a fair proportion of intracavitary cobalt 60. The percentage of high voltage therapy treatments in this group is higher than the average but could be expected as many of these larger hospitals are affiliated with a teaching center and have a therapy department which would attract therapy patients away from the general practitioner radiologist doing his own treatments.

"In 1956 the American Hospital Association reported a summary of hospitals and (beds) as 5,506 general hospitals (696,978), Tuberculosis 342 (76,380), Maternity 72 (3,108), EEN&T 48 (2,154), Psychiatric 569 (762,294), Orthopedic 81 (6,567), Contagious 12 (1,397), Chronic and Convalescent 207 (41,168) and 74 hospitals in miscellaneous categories, (10,966). All of the general hospitals of 50 beds or more have some x-ray equipment and most of the smaller hospitals with equipment usually receive service from a radiologist under the general term of rural radiology. It is estimated that the 363 residency approved departments will use the services of approximately one-third of the certified radiologists (1400) and all of the residents in radiology, as well as the radiation therapists. There are 152 physicians certified in therapeutic radiology only and most of these are affiliated with large teaching centers. With the assistance of residents the diagnostic work per radiologist each year should be greater than that of the radiologist without residents or 8,000 examinations per year for a total of 12,000,000 examinations. The remainder of the nation's 6,603 hospitals with x-ray equipment must therefore depend upon the remaining two-thirds of full time and part time radiologists for radiological service. The general hospitals with 696,978 beds admitting on the average 35 patients per bed per year will admit 23,394,430 patients and with the average of 45% of all patients having an x-ray examination after admission one can predict 10,530,000 x-ray examinations. We have shown the out-patient to in-patient ratio one plus to one but even though the total number of examinations is fewer for the out-patients we can anticipate more than 10 million additional examinations from the out-patients examined in the radiology departments of the remaining general hospitals, and the special hospitals such as tuberculosis, childrens, orthopedic and others of that group. The psychiatric hospitals with 762,294 beds take the majority of the 910,714 beds of the entire group.

"The number of therapy patients and therapy treatments has no relationship to the bed capacity of hospitals owning and operating therapy equipment. Tabulation of a number of 100-300 bed and larger hospitals showed definitely that there are many factors involved in the referral of therapy patients to one hospital instead of another of similar size and it was impossible to draw any conclusions as to percentage of therapy patients in relation to those for diagnostic procedures. In the 363 hospitals approved for radiological training the percentage of treatment patients as related to total examinations was about 15%. In the 100-250 bed hospitals in towns of 25,000-50,000 the percentage was slightly above 10%. These percentage figures are average for many hospitals and patients and cannot be applied to any one group of hospitals or area in this country.

"It is a well established fact that approximately 20% of all radiographic examinations are for the gastro-intestinal tract and usually involve two or more fluoroscopic procedures, namely the stomach and the colon. Twenty percent or one-fifth of the 37,100,000 examinations listed above would be 7,700,000 plus and with two fluoroscopic seances, either on the same day or on different days and in addition the fluoroscopic observations involving examinations of the heart, uterus and Fallopian tubes, chest, fracture reductions and other procedures entailing use of the fluoroscope one can easily account for 15,000,000 fluoroscopic examinations by radiologists each year. In addition to these examinations one must consider the photofluorographic hospital admission chest films and the nationwide chest surveys by mobile truck units conducted by state and local health departments and tuberculosis control agencies. All hospitals are not equipped for miniature film screening examinations but some states report as many as 1,000,000 such examinations per year in combined hospital admissions and the traveling mobile truck units.

"Some interesting odds and ends of information gleaned from the records of the Professional Bureau of the American College of Radiology and the various surveys can be added to this supplement. In our most recent survey with questionnaires from eight geographic locations involving 413,456 patients the statistics were sufficiently accurate for use in determining that 171,691 radiographic patients produce 221,921 radiographic examinations or 1.33 per patient. We were also able to show the following percentages of the total examinations: Head—5.7%; Bone and Joint—31%; Gastro-intestinal including the gall bladder—20.7%; G.U.—4.7% and of the genito-urinary examinations—2.6% of all examinations were for an intravenous pyelogram and .7% for a retrograde or a total of 3.3% of all radiographic examinations were classified as a kidney with contrast study. The chest examinations, exclusive of miniature film were 30.7%.

"Suggestions pertaining to construction of room size, film filing space, equipment and supplies can be outlined in the following manner. The most efficient radiographic room size is apparently 224 sq. ft., usually 14 x 16 feet. Such a room size allows 4 feet 3 inches from the center of the radiographic table to the wall or sufficient room for passage of a stretcher. It was also found that 6 feet 3 inches from the center of the table to the control booth was the best location for the table. Time and effort studies were made with technicians wearing Pedometers. The numbers on the face of the instrument were taken as arbitrary figures and not as miles walked as the Pedometers were worn on the belt and activities other than walking affected the movement of the hand on the face of the dial. If the film pass box is from a room of the above size directly into the dark room a Pedometer worn by a technician should read 4 or 4 plus per day. If the technician is required to develop films, escort patients from the waiting room to the examining room and office, etc., the reading may be as high as 6 per day. Larger rooms than the above may show a reading of as high as 5 per day with the technician handling a similar number of patients as examined in the 14 x 16 foot room. We found that fatigue began at a reading of 4 and after that technical efficiency lowered and errors increased.

"Film filing is usually in Kraft paper film filing envelopes. If each single examination is filed the space required can be measured in units with each unit containing the average of four films and one envelope. If previous and current examinations are filed together in the same envelope the average thickness of each unit becomes greater. If the units vary from 4 to 10 films per envelope 120 units can be stored in each linear foot of shelf space. Film filing space must allow for aisles, film racks and handling space. One linear foot of 14½ x 17½ filing envelopes occupies 2.3 cubic feet. 100,000 x-ray films in filing envelopes will occupy 2,500 cubic feet of space but the same number of film on microfilm will occupy only 10 cubic feet of space. Microfilming is usually done after films are removed from the current files and mirofilms on rolls are referred to 5%-6% of requests for review of inactive films the first year, second year 2% and the third year a fraction of 1%. Microfilming before interpretation assures the greatest number of radiographs of cases being in the microfilm files.

"In other time and patient control studies it was found that the ratio of orderly transported patients for a department of radiology in a general hospital was usually three wheel chair and walk patients to one stretcher case. The average patient load of the average technician was found to be 20-24 patients per day. In larger departments with many technicians and some assigned to special study cases the average daily load will remain about the same. A typist of average or better speed can transcribe 10 Dictaphone cylinders or 6 belts during an eight hour day if the average dictation is 18-20 reports per belt. The transcribing time per belt is usually one hour and fifteen minutes. One cassette per patient per day was found to be the minimum number to have available for prompt handling of patients, i.e. 30 patients per day would require a total of 30 cassettes of various sizes and in good condition. Additional cassettes above this minimum will insure an increase in efficiency and provide spares in the event of damage to cassettes or screens.

"In addition it was found that 1-1½ lbs. of fresh linen per patient per day was the average use in a hospital x-ray department. This includes sheets, pillow cases, towels, patient gowns, personnel uniforms and physicians' coats. A general hospital requires 17-18 lbs. of fresh linen per bed patient per day and the average life of a sheet or patient gown is 80 washings. 12 x-ray patient gowns weigh 8 lbs., 12 sheets 72 x 108 inches weigh 22 lbs. and 12 pillow cases 4 lbs.

"Using a relative value fee schedule for both diagnosis and for therapy an attempt was made to determine the comparative time spent as necessary to earn X dollars in therapy as it does to earn an equal amount in diagnosis. No conclusions could be made as more individuals are involved in a diagnostic procedure than in a treatment and the incomes of various places show a wide variance as related to paient load. However, it was found that with 10%-15% therapy treatments 85% of the total income was from diagnostic patients and 95% of the total costs (exclusive of medical personnel) are diagnostic costs.

"Again from the files of the Professional Bureau we find that requests for radiation therapists are few and infrequent. Most therapists are secured by direct contact with teaching centers offering complete training in therapeutic radiology. Practically all of the requests within the past year or two have been for men trained in diagnosis, therapy and isotopes. In our studies and correspondence we have been unable to detect any trend toward dividing radiology into two separate departments, namely—diagnostic and therapeutic. Such divisions do exist in the larger centers but in practically all cases the department of radiology is under one radiologist as director.

"In conclusion we hope that these statistical studies will be informative to radiologists, recent trainees and those who have been in practice for years, and in addition stimulate an interest in the value of statistical information as it pertains to the economic aspects of the practice of radiology.

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ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The United States Atomic Energy Commission is providing data on environmental levels of radioactivity in the vicinity of major Commission installations to the Public Health Service on a quarterly basis. The data are from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Radiological Health Data, Volume I, Numbers 8 and 9; and Volume II, Numbers 1 through 6 contain summaries for 17 installations. Summaries follow for Argonne National Laboratory, Oak Ridge National Laboratory and the Paducah Gaseous Diffusion Plant for the fourth quarter of 1960.

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Argonne National Laboratory

University of Chicago
Lemont, Illinois

—Issued March 16, 1961

Environmental levels of radioactivity at Argonne National Laboratory (ANL) for 1959 and first and second quarters of 1960 were reported in *Radiological Health Data,* Volume I, Number 9 and Volume II, Number 4. The following report presents a summary of the data for the third and fourth quarters of 1960.

The environmental levels of radioactivity were determined by measuring the concentrations of radioactivity in naturally occurring materials collected at the ANL site and from as far away as one hundred miles. Since air and water are the most probable media for disseminating radioactivity, the environmental monitoring program at ANL has concentrated on these materials. The air and water sampling locations discussed in this report are shown in figures 1 and 2. Other materials, such as plants, soil, and river bottom sediment, and water from locations not shown on the map are analyzed also. The results of these analyses are not included here since they are not pertinent to the evaluation of ANL's contribution to the environmental radioactivity. All the data from the radioactivity monitoring program are given in annual reports issued by ANL.

Air Monitoring

Figure 1 is a map of the ANL site which has been divided into 1,000 foot squares by a series of grid lines. Sampling points at the site are identified by specifying the square in which they are located; for example, the Sawmill Creek sampling locations are in squares 13 L and 7 M. Sampling locations off the site (figure 2) are identified by giving geographical locations.

Samples are first analyzed for their total alpha and beta particle radioactivity. These analyses provide a rapid means of assessing the general radioactivity levels of the samples and indicate whether samples contain above-normal amounts of radioactivity. Some of these samples are then analyzed for the specific elements and nuclides that are likely to be responsible for the total alpha and beta activities observed.

The hazard due to a given concentration of a radioactive isotope is assessed by comparison with the maximum permissible concentration (MPC) recommended for that isotope by the National Committee on Radiation Protection and Measurements (NCRP). For populations in the vicinity of a nuclear energy installation the applicable maximum permissible concentrations are one-tenth of the occupational MPC's given in National Bureau of Standards Handbook Number 69. These lower MPC's are used throughout this report.

Air was sampled by drawing it through the filter paper at a known rate and analyzed by measuring the radioactivity in the particles collected on the paper. Samples were collected continuously at five locations at the Argonne site and at four off-site locations near Aurora, Hinsdale, Joliet, and Tinley Park. The filter papers were changed at weekly intervals. Quarterly averages of the data are tabulated below.

TABLE 1.—RADIOACTIVITY IN AIR FILTER SAMPLES

[Average concentrations in $\mu\mu c/m^3$]

Period (1960)	Location	Number of samples	Alpha	Beta
Third quarter	On-site	68	0.008	0.09
	Off-site	50	0.007	0.09
Fourth quarter	On-site	67	0.007	0.06
	Off-site	40	0.008	0.05

The data in table 1 were obtained by measuring samples three days after they were collected in order to avoid counting the natural radioactivity due to radon and thoron products. This activity, normally present in the air and in considerably larger amounts than the activities expected from fallout or from ANL, disappears within three days by radioactive decay.

FIGURE 1.—SAMPLING LOCATIONS, ARGONNE NATIONAL LABORATORY

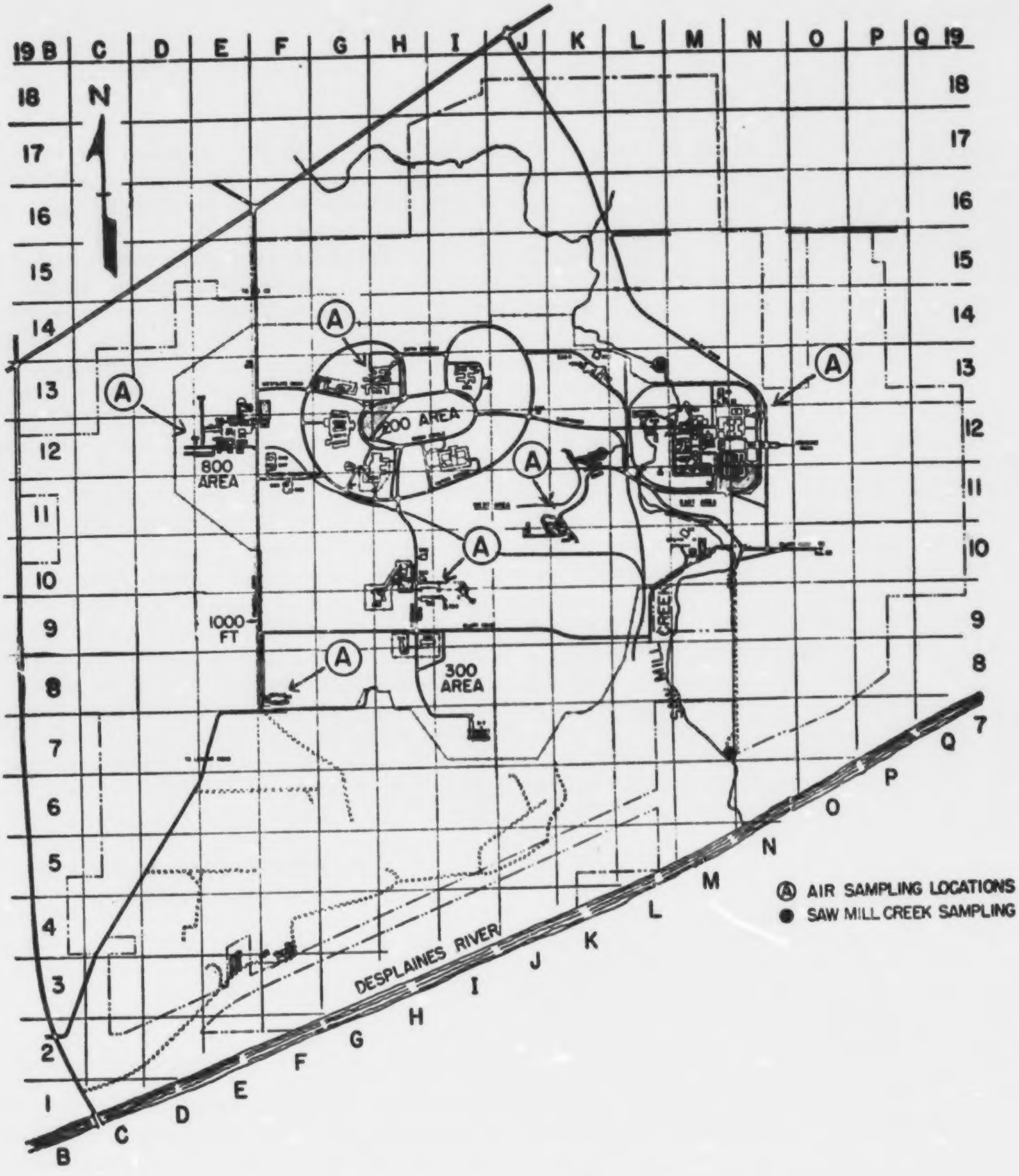

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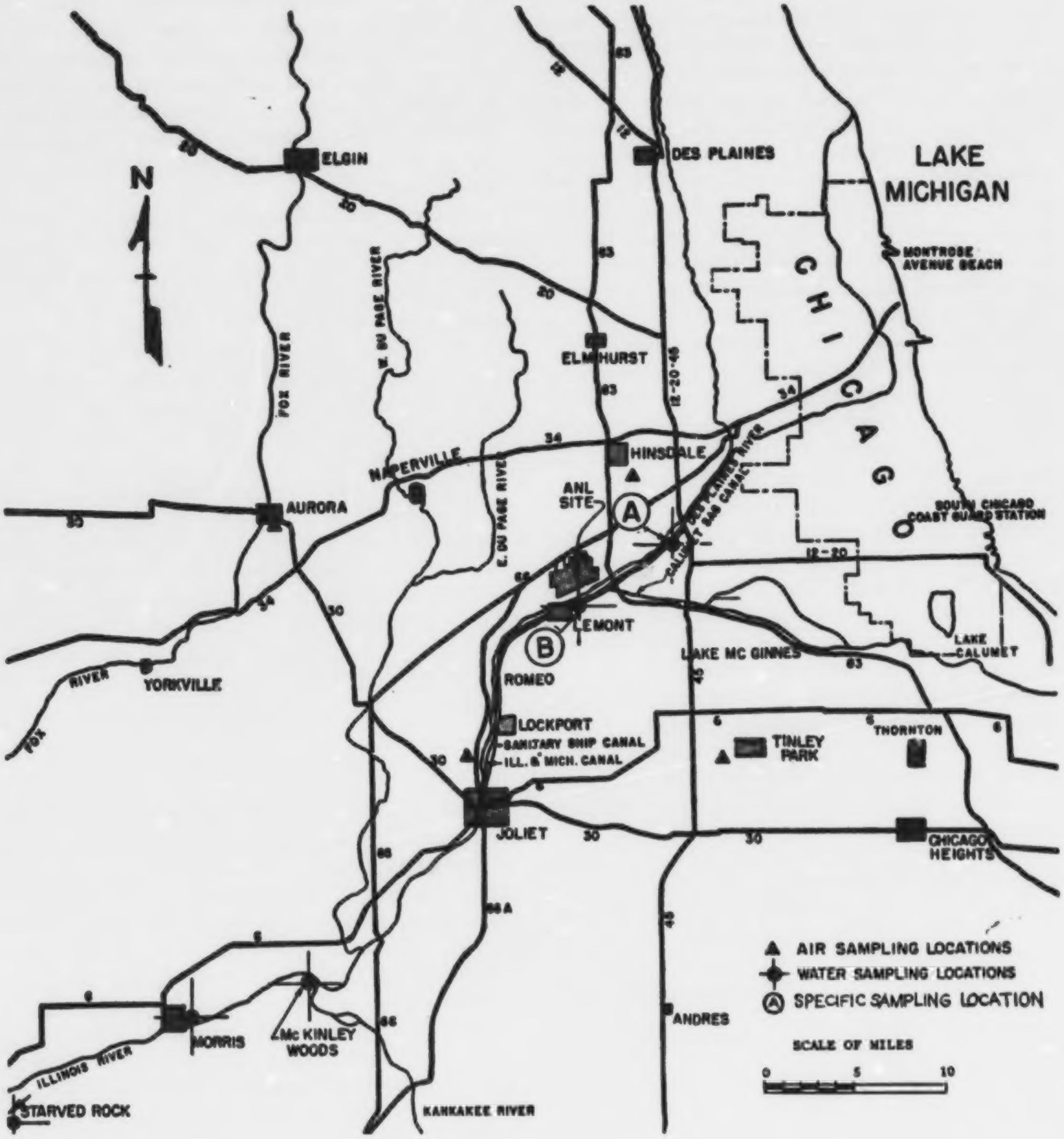
FIGURE 2.—OFF-SITE SAMPLING LOCATIONS, ARGONNE NATIONAL LABORATORY



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Within the sample collection and analytical error of 10 to 20 percent, the averages and ranges were the same both on and off the ANL site. Individual samples collected at the same time from different locations may show differences somewhat greater than this due to a variety of factors, such as the amount of dust in the air. Such differences become unimportant when comparisons are made between the averages of large numbers of samples. If activity used at ANL were discharged to the environment, higher activities would be expected on the site. Since this was not the case ANL did not add significantly to the airborne activity of the environment.

The alpha and beta activities given in the above table are due to a number of radioactive isotopes in the air sample. The application of MPC's to such mixtures is much more restrictive than in the case of a single nuclide. NBS Handbook No. 69 (page 94) recommends a series of MPC's which become progressively larger as the more toxic nuclides are eliminated from the mixture. For the samples collected near ANL, the applicable MPC is 100 μμc per cubic meter. The average activity during the last half of 1960, approximately 0.08 μμc per cubic meter, was 0.08% of the MPC.

Table 2 presents the concentrations of the principal gamma ray emitting nuclides in the air samples. This table gives additional evidence to support the conclusion stated above that ANL did not add significantly to the airborne radioactivity of the environment.

TABLE 2.—SPECIFIC NUCLIDE ACTIVITY IN AIR FILTER SAMPLES

[Average concentrations in μμc/m³]

Period (1960)	Location	Ce^{144}	Ru^{106}-Rh^{106}	Cs^{137}
Third quarter	On-site	0.023	0.049	0.013
	Off-site	0.027	0.055	0.016
Fourth quarter	On-site	0.010	0.069	0.006
	Off-site	0.009	0.059	0.006

The above results were obtained by combining and counting as one sample all of the filter papers obtained each month from each location. The results given for the ruthenium-rhodium pair of nuclides were obtained from the counting rate of gamma rays with energies in the neighborhood of 0.5 Mev. The three principal nuclides in the air samples that emit such gamma rays are beryllium-7, rhodium-102, and ruthenium-rodium-106. Since the concentration of each of these nuclides in a mixture is difficult to determine by gamma ray counting alone, and since the results are used in this report only for comparison between off-site and on-site locations, the 0.5 Mev gamma ray activity was calculated as ruthenium-rodium-106.

The random differences in gamma ray activity between on-site and off-site samples indicate that the activity originated from a widespread source and not from a localized source such as ANL. The identity of the nuclides in the air samples also supports this conclusion, since the gamma ray activities were due to the nuclides expected from fallout and natural activity. The radioactivity from ANL should contain other nuclides that were not found in the samples. The concentrations of cerium-144 and cesium-137 decrease fairly regularly from the third to the fourth quarter as would be expected for fallout activity. The activity at 0.5 Mev did not show this decrease since a substantial fraction of this activity was due to beryllium-7, which is continuously being produced in the upper atmosphere by cosmic rays.

Surface Water Monitoring

ANL waste water is analyzed for radioactivity and discharged into Sawmill Creek, a stream that runs through the ANL grounds and empties into the Des Plaines River about 500 yards downstream from the waste water outfall. Sawmill Creek was sampled upstream from the ANL site and downstream from the waste water outfall to determine if radioactivity was added to the creek in ANL waste water. The uranium and gross alpha activities found in Sawmill Creek during the third and fourth quarters of 1960 are given in the following table.

Upstream from the ANL site the alpha activity was primarily due to naturally-occurring radionuclides. The increase in alpha activity below the waste water discharge was evidently due to radioactive material added to the stream by ANL waste water. Comparison of the total alpha activity with the uranium concentrations

TABLE 3.—URANIUM AND GROSS ALPHA ACTIVITY IN SAWMILL CREEK WATER

[Average concentrations in μμc/liter]

Period (1960)	Location (see fig. 1)	Uranium		Gross alpha	
		Number of samples	Activity	Number of samples	Activity
Third quarter	13 L	13	0.9	13	1.6
	7 M	21	9.2	37	8.5
Fourth quarter	13 L	11	0.9	13	1.4
	7 M	15	6.7	36	7.5

indicates that the alpha activity added to the creek in waste water from ANL was almost entirely due to the uranium.

Since the normal creek water is diluted approximately in half by waste water, the amount of uranium naturally present in the creek below the outfall was about 0.5 μμc/liter, one half of the uranium concentration above the site. Therefore, the average uranium concentration added to the creek by waste water during last half of 1960 was approximately 7.6 μμc/liter, or 0.04 percent of the MPC for populations (1/10 of the occupational MPC). Small amounts of plutonium and thorium originating in ANL waste water were also found in Sawmill Creek below the outfall. The alpha activities due to these elements are summarized in table 4.

TABLE 4.—PLUTONIUM AND THORIUM IN SAWMILL CREEK WATER—SECOND HALF 1960

[Average concentrations in μμc/liter]

Location (see fig. 1)	Number of samples	Plutonium	Thorium
Above-site (13 L)	8	<0.05	<0.05
Below-outfall (7 M)	24	0.14	0.16

The averages in table 4 were calculated assuming a concentration of 0.025 μμc/liter (one-half of the minimum detectable amount) in those samples containing less than 0.05 μμc/liter. All above-site samples and about one-third of the below-site samples contained less than 0.05 μμc/liter.

The presence of plutonium and thorium below the outfall was due to the waste water from ANL. The average concentrations of plutonium added to the creek in Argonne waste water amounted to approximately 0.003 percent of the population MPC. For thorium the corresponding percentage of the MPC was 0.008 percent. Radium 226 and other important alpha emitting nuclides were present only in normal concentrations in the creek.

The gross beta activity found in Sawmill Creek water during the third and fourth quarter of 1960 are tabulated below.

TABLE 5.—GROSS BETA ACTIVITY IN SAWMILL CREEK WATER

[Average concentrations in μμc/liter]

Period (1960)	Location (see fig. 1)	Number of samples	Activity
Third quarter	13 L	13	5.6
	7 M	17	40.8
Fourth quarter	13 L	12	5.9
	7 M	36	31.8

Several specific beta emitting nuclides have been detected in the creek as a result of their presence in ANL waste water. The concentrations of the most important of these nuclides are summarized in table 6.

TABLE 6.—SPECIFIC NUCLIDE ACTIVITY IN SAWMILL CREEK WATER—SECOND HALF 1960

[Average concentrations in μμc/liter]

Nuclide	Location (see fig. 1)	Number of samples	Activity
Sr^{90}	13 L	8	0.6
	7 M	24	9.5
Cs^{137}	13 L	8	0.4
	7 M	23	10.2
Co^{58}	13 L	4	<3
	7 M	20	346
Co^{60}	13 L	4	<3
	7 M	20	17

The results indicate that all the cobalt-58 and cobalt-60 and the bulk of the strontium-90 and cesium-137 in the river water below the outfall originated in ANL waste water. The only nuclide present in significant concentrations relative to the MPC was strontium-90. However, 80 percent of the strontium-90 occurred in one sample collected on December 9. Excluding this sample, the average strontium-90 concentration was only 1.9 μμc/liter (1.9 percent of the population MPC). Analyses for other fission products also were made, but they were either absent or present so infrequently and in such small concentrations that they contributed negligible amounts of beta activity to the creek.

Since Sawmill Creek empties into the Des Plaines River, which in turn flows into the Illinois River, the radioactivity in the latter two streams is important. The Des Plaines River was sampled above and below the mouth of Sawmill Creek to determine if the radioactivity in Sawmill Creek had any effect on the activity in the river. The uranium and the gross alpha and beta found in the Des Plaines River during the third and fourth quarters are given in the following table.

TABLE 7.—GROSS ALPHA, BETA AND URANIUM ACTIVITIES IN DES PLAINES RIVER WATER

[Average concentrations in μμc/liter]

Period (1960)	Location (See fig. 2)	Number of samples	Alpha	Beta	Uranium
Third quarter	A	13	2.3	8.3	1.5
	B	13	2.1	8.7	1.6
Fourth quarter	A	10	2.5	10.2	1.5
	B	11	2.3	9.4	1.5

The alpha, beta, and uranium activities are in the range normally found in Des Plaines River water when fallout activity is low. There was no consistent or significant difference in activity between samples collected from the two locations. Additional water samples were obtained during July, September, and November from the Des Plaines River near Highway 34, upstream from Sawmill Creek, and near Romeo, downstream from Sawmill Creek. The alpha activities vary from 2.0 to 3.8 μμc/liter in the upstream samples and from 1.3 to 2.6 μμc/liter in the downstream samples.

The beta activities vary from 6.0 to 7.0 μμc/liter upstream to from 7.7 to 8.1 μμc/liter downstream. These activities are very similar to those found at locations A and B. The activities in the Des Plaines River were similar to those found in other streams in the Chicago area during this period. These samples from other streams contain from 0.7 to 5.2 μμc of alpha activity per liter, 5.2 to 14.9 μμc of beta activity per liter, and 0.8 to 2.2 μμc of uranium per liter.

About one third of the Des Plaines River samples also were anlyzed for plutonium, thorium, strontium-90 and cesium-137, and no differences were found between locations. In all samples the strontium-90 and cesium-137 concentrations range from less than 0.5 to 1.1 μμc per liter, the thorium concentrations from less than 0.05 to 0.06 μμc/liter, and the plutonium concentrations were all less than 0.05 μμc/liter. These items are normal for the Chicago area. The results indicate that the radioactivity in Sawmill Creek had no detectable effect on the radioactivity in the Des Plaines River. This is presumably the result of dilution of Sawmill Creek water by the much larger volume of water in the Des Plaines River.

The gross activities found in the Illinois River during the second half of 1960 are given in the following table.

TABLE 8.—GROSS ALPHA AND BETA ACTIVITY IN THE ILLINOIS RIVER, SECOND HALF 1960

[Concentrations in μμc/liter]

Location	Date (1960)	Alpha	Beta
McKinley Woods State Park	July 28	4.6	14.2
McKinley Woods State Park	September 29	1.0	6.7
McKinley Woods State Park	November 16	2.5	6.5
Morris	November 16	2.3	5.9
Starved Rock State Park	November 16	1.7	7.2

General Conclusions

Except for a large reduction in the amount of fallout activity relative to the first half of 1959, the levels of environmental radioactivity during the second half of 1960 was generally the same as described in the first report of this series.

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Oak Ridge National Laboratory

Union Carbide Nuclear Company
Oak Ridge, Tennessee

—Issued April 1961

Environmental levels of radioactivity at the Oak Ridge National Laboratory (ORNL) for 1959 and the first and second quarters of 1960 were reported in *Radiological Health Data*, Volume I, Number 9 and Volume II, Number 3. The following report presents a summary of the data for the fourth quarter of 1960.

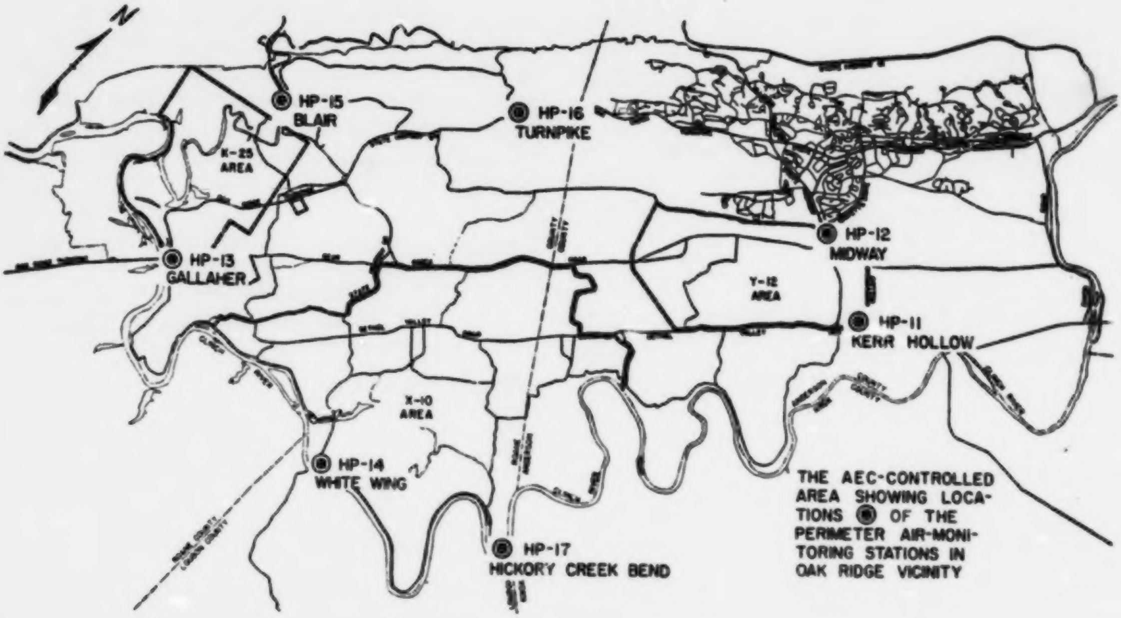
Radioactive waste materials arising from the operations of Atomic Energy Installations at Oak Ridge are collected, treated, and disposed of according to their physical states.

Air that may become contaminated by radioactive materials is exhausted to the atmosphere from several tall stacks after treatment by means of filtration, scrubbing and/or precipitation. Liquid wastes which contain long-lived fission products are confined in storage tanks or are released to pits located in a Conasauga shale formation. Low level liquid wastes are discharged after preliminary treatment to the surface streams. Solid wastes are buried in a Conasauga shale formation. This shale has a marked ability to fix radioactive materials by an ion exchange mechanism.

Air Monitoring

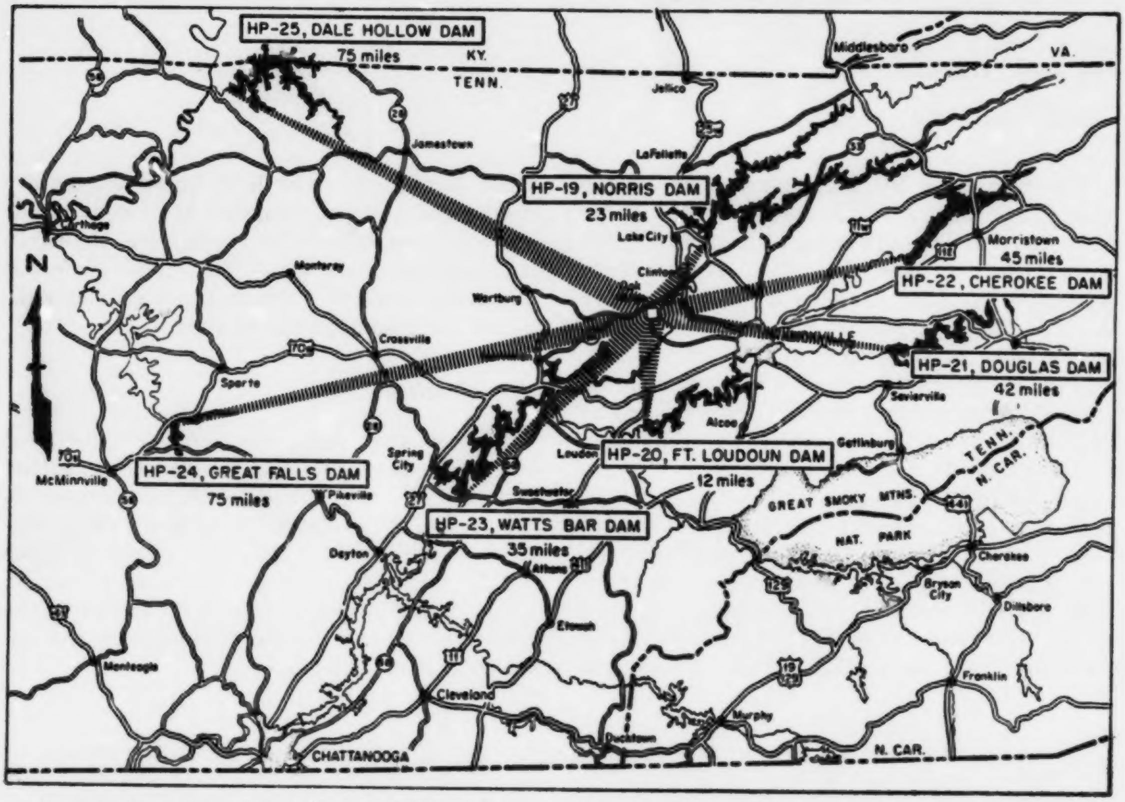
Atmospheric contamination by long-lived fission products and fall-out occurring in the general environment of east Tennessee is monitored by two systems of monitoring stations. One system consists of seven stations which encircle the plant areas as shown in figure 1 and provides data for evaluating the impact of all Oak Ridge operations on the immediate environment.

FIGURE 1.—PERIMETER AIR MONITORING STATIONS, OAK RIDGE NATIONAL LABORATORY



THE AEC-CONTROLLED AREA SHOWING LOCATIONS ● OF THE PERIMETER AIR-MONITORING STATIONS IN OAK RIDGE VICINITY

FIGURE 2.—REMOTE AIR MONITORING STATIONS, OAK RIDGE NATIONAL LABORATORY



A second system consists of eight stations located at distances of from 12 to 120 miles from Oak Ridge, as shown in figure 2. This second system provides data to aid in evaluating local conditions and to assist in determining a spread or dispersal of contamination should a major incident occur. Sampling is carried out by passing air continuously through a filter paper and thus collecting those particles considered to be respirable. Table 1 presents the air monitoring data for the fourth quarter of 1960.

TABLE 1.—AIR MONITORING DATA, FOURTH QUARTER 1960

[Average concentrations in μμc/m³]

Station number (see figs. 1 & 2)	Number of samples	Gross beta
Perimeter stations:		
HP-11	13	0.037
HP-12	13	.050
HP-13	13	.050
HP-14	13	.046
HP-15	13	.052
HP-16	13	.046
HP-17	13	.041
Average		0.046
Remote stations:		
HP-19	13	.080
HP-20	13	.049
HP-21	13	.046
HP-22	13	.041
HP-23	13	.052
HP-24	13	.049
HP-25	12	.038
HP-26	12	.034
Average		0.049

TABLE 2.—URANIUM CONCENTRATIONS IN AIR NEAR THE GASEOUS DIFFUSION PLANT, FOURTH QUARTER 1960

[Average concentrations in μμc/m³]

Distance from plant	Number of samples	Direction from plant				Average
		North	East	South	West	
[1] 2 miles	42	0.1	0.10	0.17	0.00	0.11
[2] 2 miles	16	27.0	31.2	3.9	18.0	18.8
[1] 5 miles	40	0.7	0.25	0.16	0.3	0.3
[2] 5 miles	16	16.9	9.3	4.9	1.1	1.1

[1] Reflects normal levels existing during most of the quarter.
[2] Reflects increased levels existing for a single sample period.

As shown in the table above the average airborne alpha activity in the environs of the

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Gaseous Diffusion Plant was above the normally low level. A single period of increased activity which occurred early in November was coincident with a pilot stage run being made with highly enriched uranium materials and was largely responsible for this increase. Following completion of the short run, background values were again rapidly re-established; modification of the involved process is being studied. Of the 427 eight-hour continuous samples obtained in those plant operations areas where a stack or vent discharge of uranium materials is possible, less than one percent were above the maximum permissible concentration of occupational exposure (20 $\mu\mu c/m^3$) and the average was only a small fraction of this concentration.

Water Monitoring

Large-volume, low-level liquid wastes originating at Oak Ridge National Laboratory are discharged, after some preliminary treatment, into the Tennessee River system by way of White Oak Creek and the Clinch River. Liquid wastes originating at the Oak Ridge Gaseous Diffusion Plant (K-25 area) and the Y-12 plant are discharged to Poplar Creek and thence to the Clinch River. Releases are controlled so that the resulting average concentrations in the Clinch River comply with the maximum permissible levels for populations in the neighborhood of a controlled area as recommended by the National Committee on Radiation Protection and Measurements (NCRP). The concentration of radioactivity leaving White Oak Creek is measured and concentrations values for the Clinch River are calculated on the basis of the dilution provided by the river.

Radioactive liquid wastes are sampled at a number of locations as shown in figures 4 and 5. Samples are taken at a number of locations in the Clinch River, beginning at a point above the entry of wastes into the river and ending at Center's Ferry near Kingston, Tennessee. Stream gauging operations are carried on continuously by the United States Geological Survey to obtain dilution factors for calculating the probable concentrations of wastes in the river. Water sampling stations on Poplar Creek upstream and downstream of the gaseous diffusion plant on Poplar Creek have been relocated upstream and downstream of the entry of Poplar Creek into Clinch River.

Samples are analyzed for the long-lived beta emitters, for uranium, and for the transuranic alpha emitters. Tables 3 and 4 present the results of these analyses for the fourth quarter of 1960.

Figure 3.—AIR SAMPLING STATIONS, K-25 AREA, OAK RIDGE NATIONAL LABORATORY

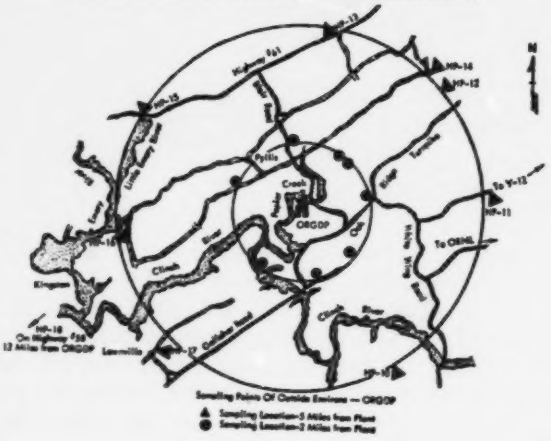


TABLE 3.—CONCENTRATIONS OF MAJOR RADIONUCLIDES IN THE CLINCH RIVER, FOURTH QUARTER 1960

[Average concentrations in $\mu\mu c$/liter]

Location (see fig. 4)	Sr^{90}	Ce^{144}	Cs^{137}	$Ru^{103-106}$	Co^{60}	Gross beta
Upstream (mi. 37.5)	0.5	0.4	ND [2]	ND	ND	1.4
Point of entry [1] (mi. 20.8)	7.1	1.6	3.9	280	8.6	700
Downstream (mi. 4.5)	13.0	1.1	1.4	400	8.1	600

[1] Calculated values based on levels of waste released and the dilution afforded by the river.

[2] Not detectable by present instrumentation.

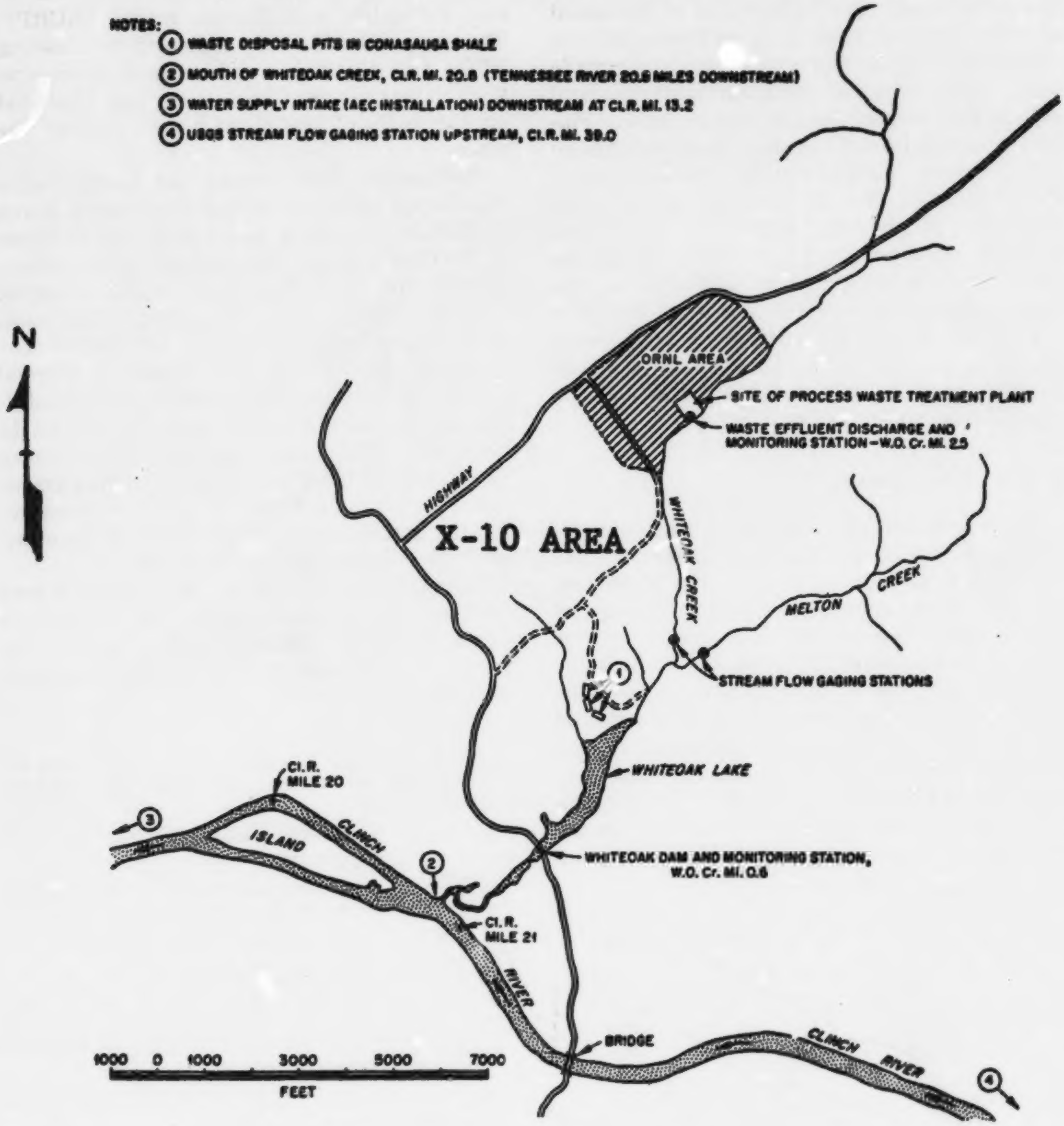
TABLE 4.—URANIUM CONCENTRATIONS IN THE CLINCH RIVER NEAR K-25 AREA, FOURTH QUARTER 1960

[Average concentrations in $\mu\mu c$/liter]

Location (See fig. 5)	Number of samples [1]	Uranium concentration
Upstream from K-25	7	1.4
Downstream from K-25	7	2.7

[1] Normal sampling frequency: Continuous sampling composited over one week.

FIGURE 4.—LOCATION MAP, OAK RIDGE NATIONAL LABORATORY

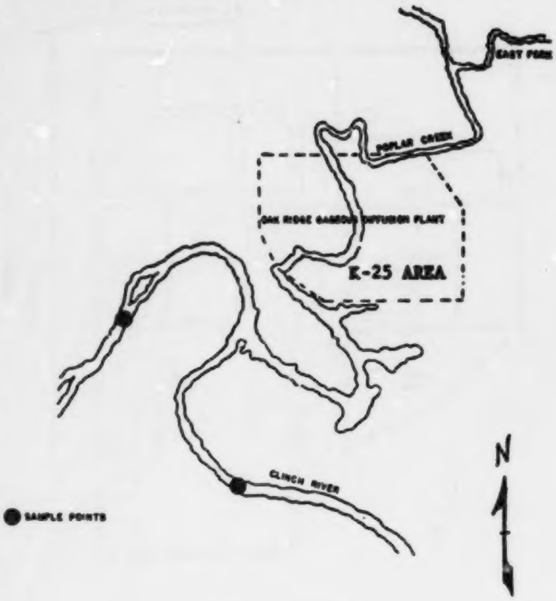

NOTES:
① WASTE DISPOSAL PITS IN CONASAUGA SHALE
② MOUTH OF WHITEOAK CREEK, CL.R. MI. 20.8 (TENNESSEE RIVER 20.6 MILES DOWNSTREAM)
③ WATER SUPPLY INTAKE (AEC INSTALLATION) DOWNSTREAM AT CL.R. MI. 13.2
④ USGS STREAM FLOW GAGING STATION UPSTREAM, CL.R. MI. 39.0
N
ORNL AREA
SITE OF PROCESS WASTE TREATMENT PLANT
WASTE EFFLUENT DISCHARGE AND MONITORING STATION—W.O. Cr. MI. 2.5
HIGHWAY
X-10 AREA
WHITEOAK CREEK
MELTON CREEK
STREAM FLOW GAGING STATIONS
①
WHITEOAK LAKE
Cl.R. MILE 20
③
ISLAND
CLINCH
②
WHITEOAK DAM AND MONITORING STATION, W.O. Cr. MI. 0.6
Cl.R. MILE 21
RIVER
BRIDGE
CLINCH RIVER
④
1000 0 1000 3000 5000 7000
FEET

The rise in concentrations of radioactivity in the Clinch River during this quarter reflects an increase in the quantity of radioactive materials discharged.

External Gamma

External gamma radiation levels are measured monthly at a number of locations in the Oak Ridge area. Measurements are taken with a Geiger-Muller tube at a distance of three feet above the ground. The results are tabulated in table 5. The levels in the table below are not significantly different from the average of the levels measured throughout the United States by the Public Health Service Radiation Surveillance Network.

FIGURE 5.—WATER SAMPLING STATIONS, K-25 AREA, OAK RIDGE NATIONAL LABORATORY



Conclusions

From the data presented, it seems evident that the Oak Ridge operations are contributing little to the air or ground contamination in the neighborhood of the area controlled by the Atomic Energy Commission. Some radioactivity has been contributed to the Clinch River by the release of radioactive liquid wastes, but concentrations of radioactivity in the river are well below the maximum permissible concentrations recommended by the NCRP for populations living in the vicinity of an atomic energy installation.

TABLE 5.—EXTERNAL GAMMA RADIATION LEVELS, FOURTH QUARTER 1960

[Average levels in mr/hr at 3 feet above ground]

Location (see fig. 1)	External gamma
Solway Gate	0.013
Y-12 East Portal	.013
Newcomb Road, Oak Ridge, Tenn.	.014
Gallaher Gate	.017
White Wing Gate	.016

Paducah Gaseous Diffusion Plant

Union Carbide Nuclear Company
Paducah, Kentucky

—Issued February 1961

Environmental levels of radioactivity at the Paducah Gaseous Diffusion Plant have been reported in *Radiological Health Data,* Volume I, Number 9, and Volume II, Number 3. The following report presents a summary of the data for the fourth quarter 1960.

The Paducah Plant is a Government owned gaseous diffusion plant operated by Union Carbide Nuclear Company for the Atomic Energy Commission. The gaseous diffusion plant and the associated uranium hexafluoride manufacturing plant and uranium metal foundry process large quantities of relatively pure uranium compounds. The major sources of external penetrating radiation from such materials are the daughter-product isotopes of thorium and protoactinium formed by alpha decay and subsequent beta decay of the parent uranium. These isotopes are concentrated in the ash produced during the fluorination process. The element uranium can be a physiological hazard only if it enters the body. The chemical toxicity of the uranium materials processed at the Paducah Plant overshadows any radiation danger from this element, making it a physiological risk comparable to lead, mercury, or other well-known heavy metals.

Uranium is a rather expensive material, and thus represents a great incentive to recover as much as is economically feasible. To protect the population and to maintain a wholesome relationship with neighboring communities and individuals, the air is exhausted through filters, and all effluent waters are discharged at extremely low concentrations of uranium.

Since no recovery process or filtering system is 100 percent efficient, an environmental monitoring program is used to evaluate the effectiveness of such measures. The Paducah Plant Environmental Monitoring Program consists of a continuing system for sampling air in four stations around the plant perimeter fence, and for sampling water at two locations in Big Bayou Creek, and four locations on the Ohio River as shown in figures 1 and 2. Tables 1 and 2 present the air and water monitoring data from the fourth quarter of 1960.

FIGURE 1.—AIR SAMPLING POSITIONS, PADUCAH GASEOUS DIFFUSION PLANT

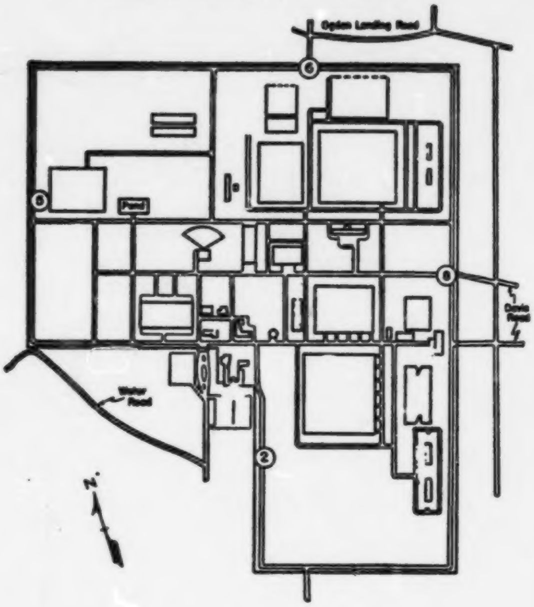


TABLE 1.—GROSS AIR ACTIVITY—FOURTH QUARTER 1960

[Average concentrations in $\mu\mu c/m^3$]

Location number (see fig. 1)	Number of samples	Uranium	Gross beta
2	12	<0.07	0.35
5	12	<0.07	<0.30
6	12	0.09	1.07
8	12	<0.07	0.44

TABLE 2.—GROSS STREAM WATER ACTIVITY—FOURTH QUARTER 1960

[Average concentrations in $\mu\mu c$/liter]

Location		Uranium		Gross beta	
Number (see fig. 2)	Description	Number of samples	Activity	Number of samples	Activity
3	Big Bayou leaving Government Land	16	[1] 1,590	13	200
4	Big Bayou at Ogden Bridge Road	6	200	3	600
9	Ohio River above Paducah Plant	6	<1	6	100
53	Ohio River below Paducah Plant	6	<1	6	200
51	Ohio River-south side at Joppa	6	<1	6	100
52	Ohio River-middle at Joppa	6	<1	6	100

[1] This group had a sample with a maximum value of 24,400 $\mu\mu c$/liter.

A micromicrocurie for recently extracted uranium, as defined in NBS Handbook No. 69, page 15, paragraph 3.2 is that amount of U^{238}, U^{235} and U^{234} which emits alpha particles at a rate 0.0849 disintegrations per second.

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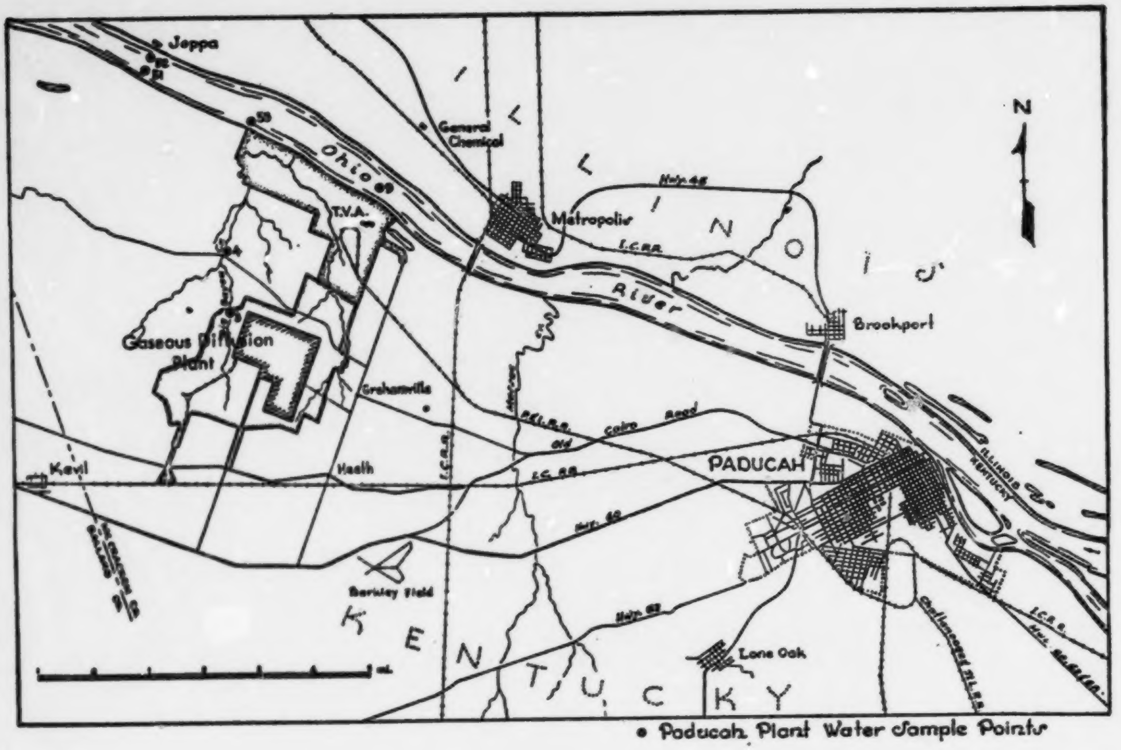
FIGURE 2.—WATER SAMPLING LOCATIONS, PADUCAH GASEOUS DIFFUSION PLANT



RADIOLOGICAL HEALTH DATA

MONTHLY REPORT **AUGUST 1961**

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SECTION I. — AIR

Radiation Surveillance Network

Division of Radiological Health, Public Health Service

The Public Health Service Radiation Surveillance Network was established in 1956 in cooperation with the Atomic Energy Commission to provide a means of promptly determining increases in levels of environmental radioactivity due to fallout from nuclear weapons tests. Although no nuclear tests have been conducted by the United States since 1958, the program has proved sufficiently valuable that it has been extended to a year-round basis. Currently, it consists of 45 stations at urban locations (see figure 1) operated by State and local health department personnel with 2 stations operated by Public Health Service personnel.

Measurements of gross beta radioactivity in air have been taken since they provide one of the earliest and most sensitive indications of increases of activity in the environment and thus act as an "alert" system. A direct evaluation of biological hazards is not possible from these data alone. Field measurements with a portable survey meter enable the operator to estimate the amount of beta activity of particulates in air at the station five hours after collection by comparison with a known source. The filters are then forwarded to the central laboratory of the Radiation Surveillance Network in Washington, D.C., for a more refined measurement using a thin window proportional counter. The stations located at Atlanta, Georgia, and Cincinnati, Ohio, conduct their own laboratory analyses.

Air samplers are in operation at the 45 stations on an average of 70 percent of the week. Air is drawn through a cellulose carbon-loaded dust filter using a high volume air sampler. The radioactive material in fallout adhering to small particles is retained on the filter. Some gaseous fission products are adsorbed by the carbon. The contribution by gaseous fission products has represented only a small part of the total beta activity in these samples. About 85 percent of the stations collect samples of precipitation which are sent to Washington, D.C., for analysis. Values are now below limits of detection by present instrumentation.

Tables 1 and 2 summarize the data for March 1961.

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS

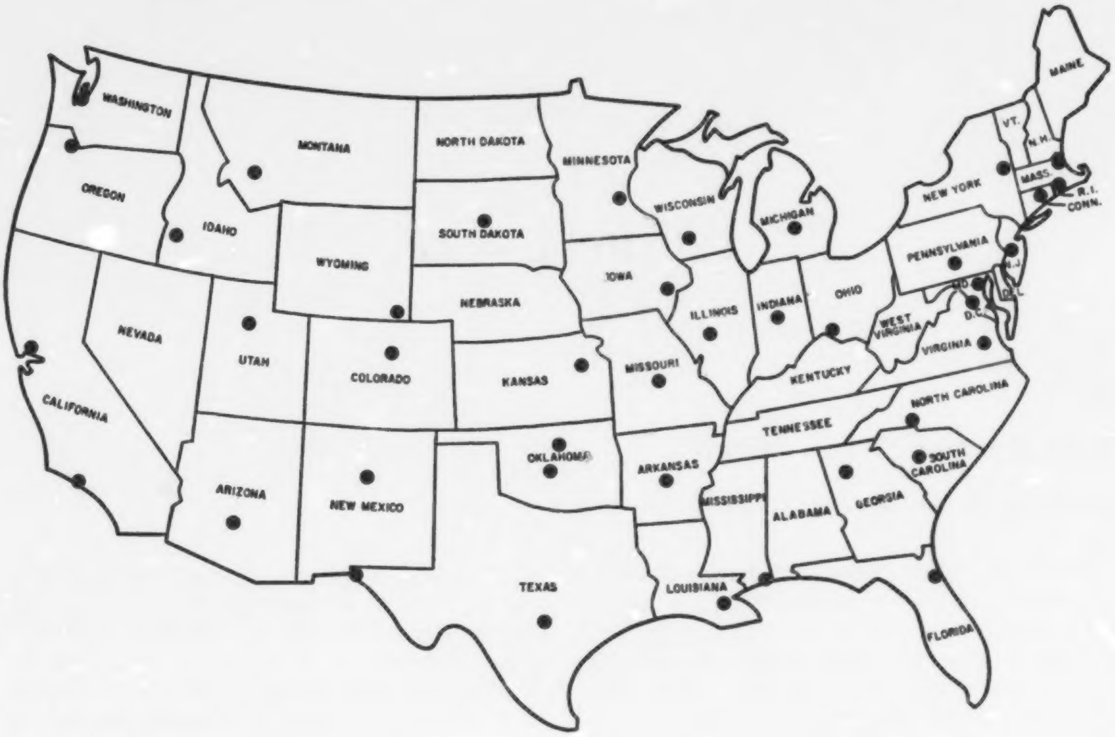

TABLE 1.—RADIOACTIVITY OF PARTICULATES IN AIR-GROSS BETA DETERMINATIONS, MARCH 1961

Station location	Number samples	Maximum ($\mu\mu c/m^3$)	Minimum ($\mu\mu c/m^3$)	Average [1] ($\mu\mu c/m^3$)	Station location	Number samples	Maximum ($\mu\mu c/m^3$)	Minimum ($\mu\mu c/m^3$)	Average [1] ($\mu\mu c/m^3$)
Anchorage, Alaska	23	0.18	<0.10	<0.11	Minneapolis, Minn	9	<0.10	<0.10	<0.10
Fairbanks, Alaska	22	0.15	<0.10	<0.10	Pascagoula, Miss	20	0.29	<0.10	<0.16
Juneau, Alaska	23	0.11	<0.10	<0.10	Jefferson City, Mo	22	0.11	<0.10	<0.10
Phoenix, Ariz	6	0.20	<0.10	<0.17	Helena, Mont	5	<0.10	<0.10	<0.10
Little Rock, Ark	20	0.15	<0.10	<0.11	Trenton, N.J	12	0.22	<0.10	<0.12
Berkeley, Calif	23	0.12	<0.10	<0.10	Santa Fe, N.Mex	21	0.25	<0.10	<0.16
Los Angeles, Calif	21	0.15	<0.10	<0.11	Albany, N.Y	31	0.15	<0.10	<0.10
Denver, Colo	21	0.18	<0.10	<0.12	Gastonia, N.C	20	0.19	<0.10	<0.11
Hartford, Conn	31	0.18	<0.10	<0.10	Oklahoma City, Okla	19	0.15	<0.10	<0.12
District of Columbia	25	0.20	<0.10	<0.11	Ponca City, Okla	27	<0.10	<0.10	<0.10
Jacksonville, Fla	23	0.20	<0.10	<0.11	Portland, Oreg	21	0.12	<0.10	<0.10
Atlanta, Ga	14	<0.10	<0.10	<0.10	Harrisburg, Pa	22	0.18	<0.10	<0.10
Honolulu, Hawaii	20	<0.10	<0.10	<0.10	Providence, R.I	23	0.20	<0.10	<0.11
Boise, Idaho	9	0.19	<0.10	<0.13	Columbia, S.C	10	0.15	<0.10	<0.11
Springfield, Ill	9	<0.10	<0.10	<0.10	Pierre, S.Dak	8	0.23	<0.10	<0.12
Indianapolis, Ind	30	0.13	<0.10	<0.10	Austin, Tex	22	0.21	<0.10	<0.11
Iowa City, Iowa	23	0.13	<0.10	<0.10	El Paso, Tex	20	0.46	0.18	0.28
Topeka, Kans	23	0.14	<0.10	<0.10	Salt Lake City, Utah	30	0.19	<0.10	<0.11
New Orleans, La	4	0.14	<0.10	<0.10	Richmond, Va	23	0.12	<0.10	<0.10
Baltimore, Md	22	0.13	<0.10	<0.10	Seattle, Wash	21	<0.10	<0.10	<0.10
Lawrence, Mass	22	0.12	<0.10	<0.10	Madison, Wis	25	0.11	<0.10	<0.10
Lansing, Mich	30	0.14	<0.10	<0.11	Cheyenne, Wyo	8	0.15	<0.10	<0.11

[1] Weighted average obtained by summing the products of individual sampling times and the corresponding activities, and dividing by the summation of the individual sampling times.

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TABLE 2.—RADON AND THORON MEASUREMENTS AT CINCINNATI, OHIO, FEBRUARY 27–MARCH 24, 1961

End of sampling period	Continuous sample collection			Radon[a] a.m. (μμc/m³)	Radon-[b] thoron p.m. (μμc/m³)	Thoron[c] (μμc/m³)	Beta[d] activity (μμc/m³)
	Sample change time	Sample period (hours)	Volume				
Feb. 27	0810	72.0	86.2	400	120	1.9	0.04
28	0814	24.1	29.0	50	60	0.7	0.05
Mar. 1	0828	24.2	29.6	90	50	0.4	0.01
2	0815	23.8	28.6	120	60	1.3	0.02
3	0800	23.7	28.7	150	80	0.3	0.08
6	0807	72.1	86.0	70	100	0.8	0.06
7	0809	24.0	28.8	140	50	0.8	0.08
8	0809	24.0	29.1	170	120	0.8	0.06
9	0810	24.0	28.3	40	170	0.4	0.01
10	0800	23.8	29.0	50	30	0.3	0.01
13	0814	72.2	86.4	130	40	1.8	0.08
14	0819	23.3	27.9	110	40	0.3	0.00
15	0818	24.0	28.1	110	110	0.8	0.02
16	0807	23.8	28.5	80	60	0.4	0.02
17	0812	24.1	29.1	50	60	0.7	0.00
20	0810	72.0	85.8	120	30	1.1	0.06
21	0816	24.1	28.6	120	60	0.7	0.09
22	0806	23.8	29.0	140	100	1.0	0.06
23	0805	24.0	28.6	110	130	0.3	0.06
24	0822	24.3	28.9	140	90	0.6	0.02
			Average	120	78	0.8	0.04

---

[a] Radon concentrations are derived from alpha measurements determined immediately after the sampling period (24 to 72 hours) has ceased. Reported radon concentrations have been corrected for any thoron daughter interferences. Twice the standard deviation (2σ) falls between ±11 and ±35 μμc/m³.

[b] Radon concentrations are derived from alpha measurements made in the afternoon (3 p.m.) approximately 7 hours after the new sampling period has begun. Therefore, the reported values were actually determined one working day prior to the date reported here. Reported radon concentrations are uncorrected for any thoron daughter interferences. Twice the standard deviation (2σ) falls between ±10 and ±22μμc/m³.

[c] Thoron concentrations are derived from alpha measurements referred to in footnote (a) but are counted 7 hours after the sampling period has ceased. Reported values are corrected to the time of removal of the filter holder. Twice the standard deviation (2σ) falls between ±0.2 and ±0.5μμc/m³.

[d] Gross beta concentrations are based on measurements made at least 4 days after the end of each sampling period (24 to 72 hours). Twice the standard deviation (2σ) falls between +0.01 and ±0.04μμc/m³.

Sampling Programs For Radioactivity In Air

The following article is the first in a series of discussions intended to present summaries of atmospheric levels of radioactivity. This article summarizes surface air fission product gross beta concentration determined by the Radiation Surveillance Network, Public Health Service, at various locations throughout the United States during the period 1957–1960. The presentation and data were compiled by Messrs. Roscoe H. Goeke, John G. Bailey, and Andreas P. Zizos of the Data Collation and Analysis Unit, Division of Radiological Health, Public Health Service.

The authors wish to express their appreciation to the Program Operations Branch, Division of Radiological Health, for supplying the basic data necessary for this presentation, and to the staff of the Atmospheric Radioactivity Research Project, U.S. Weather Bureau, for their review of the text.

Radiation Surveillance Network, Surface Air Fission Product Gross Beta Determinations

Division of Radiological Health, Public Health Service

Introduction

The Public Health Service, by an agreement in April 1956 with the Division of Biology and Medicine, U.S. Atomic Energy Commission, established a nationwide Radiation Surveillance Network with its central laboratory located in Washington, D.C. The Network was originally established to perform surveillance activities during Operation Redwing, conducted May through July 1956 at the Eniwetok Proving Grounds. The Network commenced operation in April and ceased intensive operation in September of that year. Data were received from Hawaii, Alaska and twenty-eight other states.

An extension of the Public Health Service–Atomic Energy Commission agreement in April 1957 provided a resumption of intensive sampling during Operation Plumbbob (May–October 1957) at the Nevada Test Site, (NTS) and since July 1960 the Network has been financially supported by the Public Health Service.

The Network's fission product gross beta surveillance activities were of sufficient value that sampling was extended to a 24-hour year-round basis. Currently, the network consists of 45 permanent urban stations, 43 of which are operated by State, Territorial or local health departments, and 2 by the Public Health Service.

Figure 1 illustrates the geographic location of the collection stations, and table 1 presents their respective coordinates and elevation.

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS

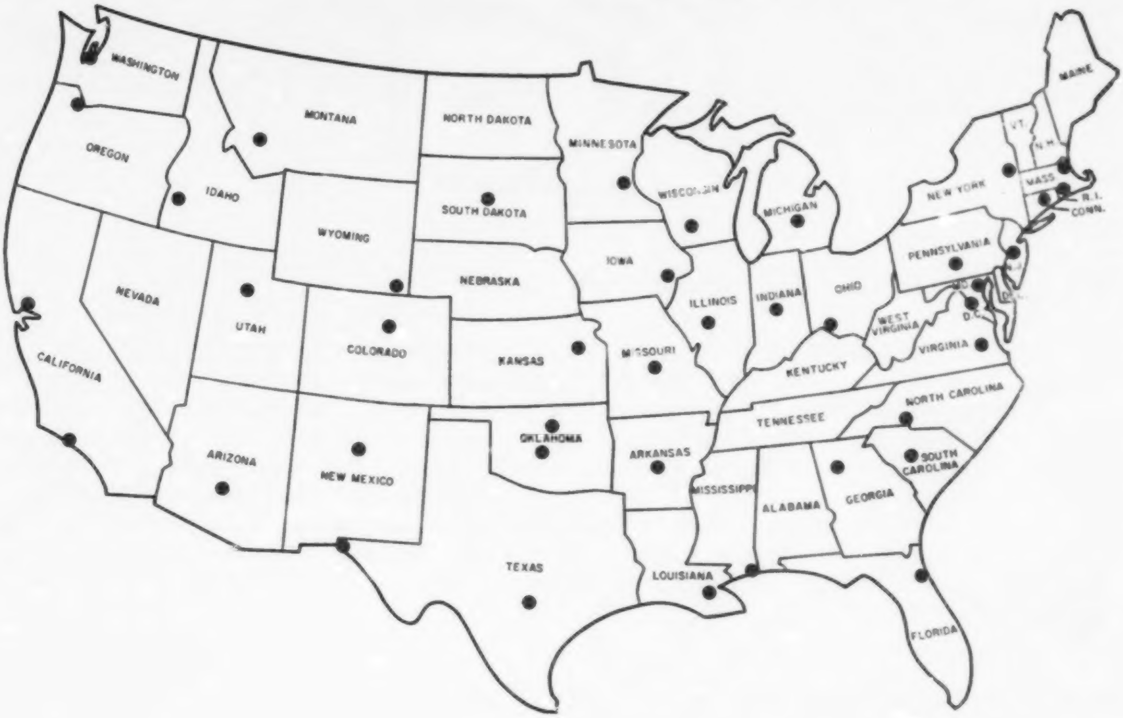

TABLE 1.—COLLECTION SITES, RADIATION SURVEILLANCE NETWORK, 1961

Station location	Latitude	Longitude	Elevation (meters)	Station location	Latitude	Longitude	Elevation (meters)
Albany, N.Y	42° 42′ N	73° 46′ W	26	Klamath Falls, Oreg	42° 12′ N	121° 48′ W	1332
Anchorage, Alaska	61 10 N	149 45 W	28	Lansing, Mich	42 45 N	84 35 W	256
Atlanta, Ga.[1]	33 45 N	84 25 W	345	Las Vegas, Nev.[1,2]	36 11 N	115 09 W	632
Austin, Tex	30 16 N	97 43 W	198	Lawrence, Mass	42 41 N	71 11 W	16
Baltimore, Md	39 18 N	76 38 W	43	Little Rock, Ark	34 43 N	92 16 W	92
Belle Fourche, S.Dak.[2]	44 39 N	103 40 W	920	Los Angeles, Calif	35 00 N	118 12 W	101
Berkeley, Calif	37 52 N	122 18 W	98	Madison, Wis	43 04 N	89 23 W	265
Boise, Idaho	43 38 N	116 12 W	866	Minneapolis, Minn	44 57 N	93 15 W	255
Cheyenne, Wyo	41 09 N	104 48 W	1861	New Orleans, La	30 00 N	90 05 W	16
Cincinnati, Ohio	39 06 N	84 30 W	191	Oklahoma City, Okla	35 28 N	97 31 W	378
Columbia, S.C	34 00 N	81 02 W	90	Pascagoula, Miss	30 21 N	88 33 W	3
Denver, Colo	39 45 N	105 00 W	1618	Phoenix, Ariz	33 27 N	112 04 W	337
El Paso, Tex	31 46 N	106 28 W	1148	Pierre, S.D	44 22 N	100 20 W	448
Fairbanks, Alaska	64 44 N	147 39 W	133	Ponca City, Okla	36 43 N	97 06 W	310
Gastonia, N.C	35 16 N	81 12 W	247	Portland, Oreg	45 30 N	122 37 W	48
Harrisburg, Pa	40 16 N	76 50 W	115	Providence, R.I	41 50 N	71 25 W	23
Hartford, Conn	41 45 N	72 40 W	12	Richmond, Va	37 34 N	77 26 W	29
Helena, Mont	46 36 N	112 01 W	1252	Salt Lake City, Utah	40 45 N	111 51 W	1324
Honolulu, Hawaii	21 18 N	157 51 W	4	Santa Fe, N.Mex	35 40 N	106 05 W	2133
Indianapolis, Ind	39 45 N	86 10 W	233	Seattle, Wash	47 45 N	122 25 W	36
Iowa City, Iowa	41 39 N	91 32 W	209	Springfield, Ill	39 47 N	89 38 W	196
Jacksonville, Fla	30 20 N	81 40 W	13	Topeka, Kans	39 03 N	95 40 W	304
Jefferson City, Mo	38 35 N	92 12 W	191	Trenton, N.J	40 14 N	74 44 W	18
Juneau, Alaska	58 20 N	134 35 W	24	Washington, D.C	38 55 N	77 00 W	22

[1] Operated by the Public Health Service.
[2] Inactivated.

Summary of Results, 1957-1960

Figure 2 is a presentation of quarterly average surface-air measurements made at stations located in latitude class intervals whose midpoints are 30°, 35°, 40°, and 45° North. Each quarter is shown as four separate graphs to illustrate variations in surface-air fission product gross beta concentrations (ordinate-logarithmic) as a function of longitude, West (abscissa-linear).

Data for the years 1957–1960 are shown in each quarter with the exception of the first. A graphical presentation was impossible in this case because of insufficient data. Data for stations located in Anchorage, Juneau, and Fairbanks, Alaska, and Honolulu, Hawaii, were not incorporated into figure 4, since the latitudes of these four stations do not correspond to those presented in this figure.

Quarterly averages with at least one month's data having a value less than the minimum detectable activity (0.10 $\mu\mu c/m^3$) are presented as an "X" within a circle. In such cases, the minimum detectable activity was used for the purpose of computing a quarterly average. Therefore, an "X" within a circle represents the maximum possible average for a particular quarter.

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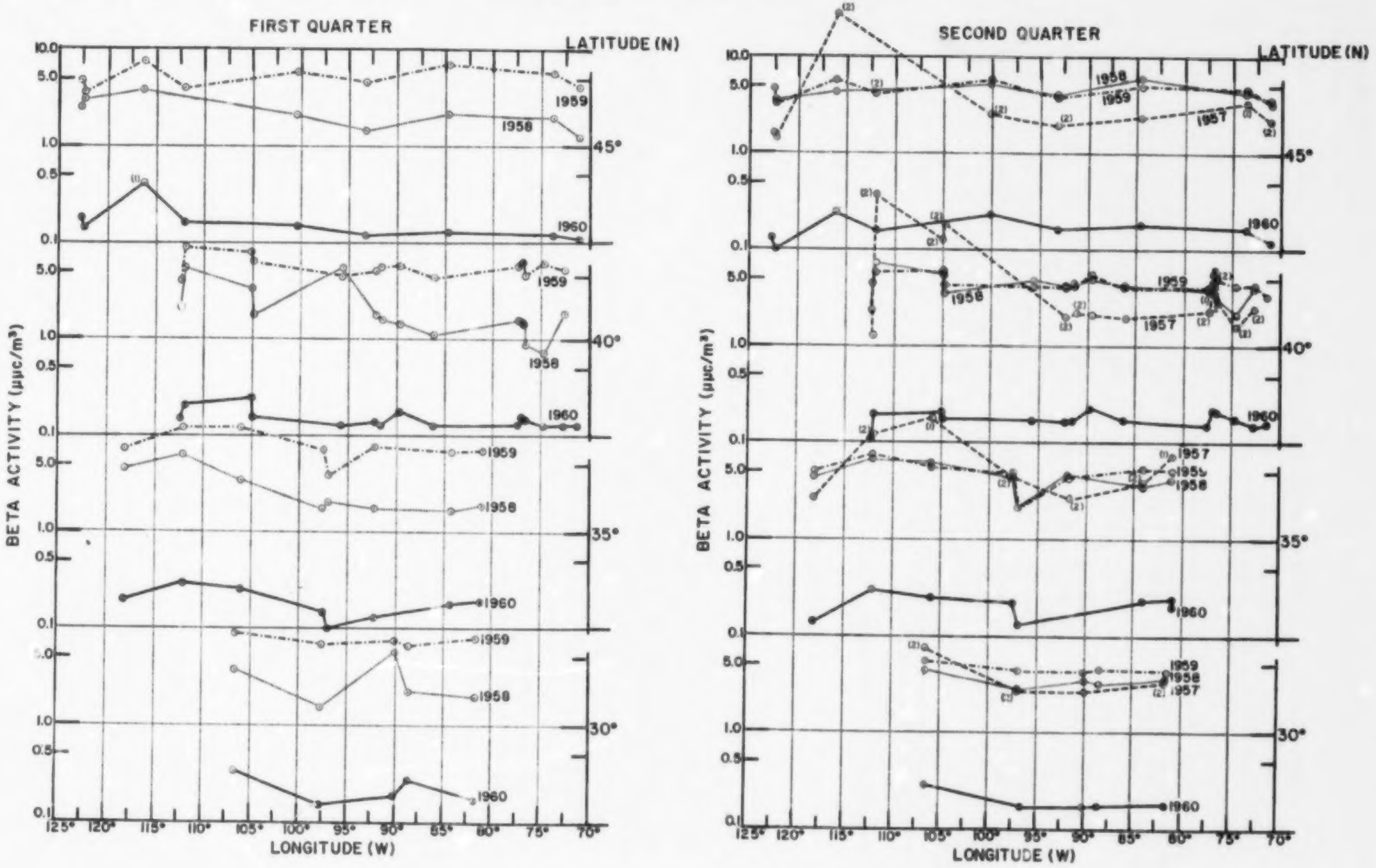
FIGURE 2.—SURFACE AIR GROSS BETA DETERMINATIONS A PRESENTATION OF QUARTERLY DATA DERIVED FROM SELECTED SAMPLING STATIONS LOCATED IN THE U.S.A. NEAR THE 30th, 35th, 40th AND 45th LATITUDES (N)



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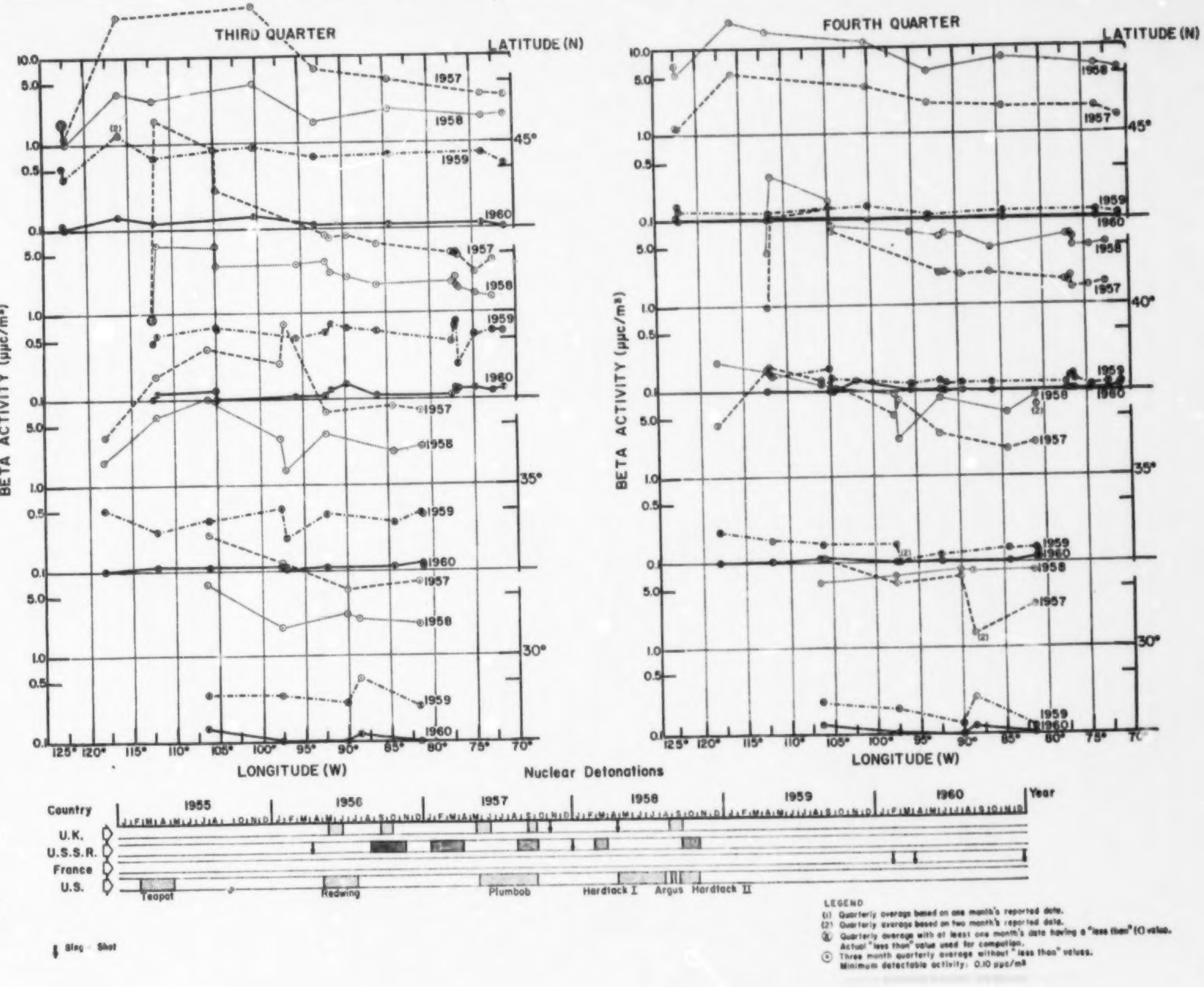
THIRD QUARTER
FOURTH QUARTER
LATITUDE (N)
45°
40°
35°
30°
BETA ACTIVITY (μμc/m³)
10.0
5.0
1.0
0.5
0.1
1957
1958
1959
1960
(2)
LONGITUDE (W)
125° 120° 115° 110° 105° 100° 95° 90° 85° 80° 75° 70°
Nuclear Detonations
Country
U.K.
U.S.S.R.
France
U.S.
Year
1955
1956
1957
1958
1959
1960
J F M A M J J A S O N D
Teapot
Redwing
Plumbob
Hardtack I
Argus
Hardtack II
Sing. Shot
LEGEND
(1) Quarterly average based on one month's reported data.
(2) Quarterly average based on two month's reported data.
Quarterly average with at least one month's data having a "less than" (<) value. Actual "less than" value used for computation.
⊙ Three month quarterly average without "less than" values.
Minimum detectable activity: 0.10 μμc/m³

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Certain trends are revealed by a qualitative examination of the yearly data by quarters. In the first quarter, surface-air gross beta concentrations along all four latitudes were highest in 1959, lower in 1958, and the lowest concentrations were encountered in 1960. The limited amount of data for 1957 indicate that concentrations for that year fell between those for 1958 and 1960.

In the second quarter, from approximately 80°–100° longitude West, the highest concentrations occurred during 1959 and 1958, with concentrations somewhat lower in 1957, and lowest in 1960. From approximately 100°–120° longitude West, the picture changes, the highest concentrations occurring during 1957.

Third quarter concentrations decreased progressively from 1957 through 1960.

Fourth quarter concentrations were highest in 1958. In general, concentrations were lower in 1957, except for the 30th and possibly 35th latitude from approximately 100°–120°, West, where they appear to be somewhat greater than 1958. The concentrations were still lower in 1959, and minimal in 1960.

An analysis of fission product surface gross beta measurements, for the period 1957–1960, reveals that the highest concentrations occurred in the third quarter of 1957; the highest concentrations in 1958, which were less than 1957, occurred in the fourth quarter; and the highest concentrations in 1959, which were less than 1958, occurred in the first quarter. In 1960, maximum concentrations along the 35th, 40th, and 45th latitudes, North, occurred in the second quarter, and in the first quarter along the 30th. The lowest concentrations occurred in the last quarter of 1960.

It is a reasonable assumption that the high concentrations shown in 1957 can be attributed to the Plumbbob series at the NTS and the Soviet tests in the earlier months of that year. The Soviet detonations in February–March and September–November 1958 are, in the same manner, related to high concentrations occurring in the fourth quarter of 1958 and the first quarter of 1959. The increase in debris in the first and second quarters of 1960, over the last quarter of 1959, is attributed to seasonal increase due to stratospheric deposition and to the French detonations of February and April 1960.

References

(1) AEC Quarterly Statements on Fallout.

(2) Joint Committee on Atomic Energy Congressional Hearings on Radioactive Fallout, Part I, 1957.

(3) *Radiological Health Data,* Vol. I, Numbers 1–9, 1960.

(4) *Radiological Health Data,* Vol. II, Numbers 1–4, 1961.

Radioactivity Measurements In Air

U.S. Naval Research Laboratory

Radioactivity measurements of air-filter samples collected at various sites near the 80th Meridian (West) are made by the U.S. Naval Research Laboratory under a program partially financed by the Atomic Energy Commission.

The daily record of fission product beta activity during March 1961 is presented in table 1, and the radioactivity profile for the same month and the first quarter 1961 are shown in figure 1. This figure illustrates the data plotted in semi-logarithmic coordinates. The ordinate is expressed in micromicrocuries per cubic meter of surface air. The concentrations in table 1 are expressed in disintegrations per minute per cubic meter of air at the collecting site (2.2 disintegrations per minute per cubic meter equals 1 micromicrocurie per cubic meter).

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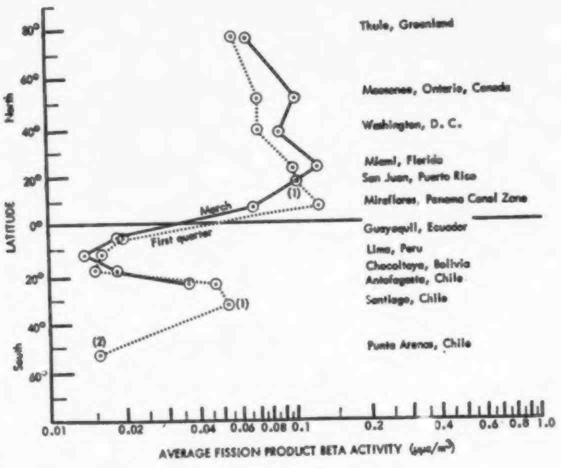
TABLE 1.—DAILY RECORD OF FISSION PRODUCT BETA ACTIVITY COLLECTED BY AIR FILTRATION, MARCH 1961

[Disintegrations per minute per cubic meter]

Day	Puerto Montt, Chile	Antofagasta, Chile	Chacaltaya, Bolivia	Lima, Peru	Guayaquil Ecuador	Miraflores, Panama Canal Zone	Mauna Loa, Hawaii	Miami, Florida	Washington D. C.	Moosonee, Ontario, Canada	Thule, Greenland
1	----------	0.15	0.04	0.06	0.05	0.08	0.07	0.31	0.16	0.19	0.13
2	----------	0.20	0.02	0.04	0.07	0.09	0.10	0.08	0.13	0.20	0.20
3	----------	0.20	0.02	0.04	0.04	0.09	0.10	0.08	0.13	0.20	0.20
4	----------	0.03	0.02	0.03	0.04	0.13	0.24	0.12	0.20	0.22	0.13
5	----------	0.03	0.02	0.03	0.05	0.13	0.24	0.12	0.20	0.22	0.13
6	----------	0.03	0.02	0.03	0.05	0.13	0.24	0.12	0.20	0.22	0.13
7	----------	0.14	0.02	0.04	0.02	0.18	0.22	0.11	0.16	0.24	0.16
8	----------	0.14	0.02	0.04	0.02	0.18	0.22	0.11	0.16	0.24	0.16
9	----------	0.08	0.02	0.06	0.02	0.18	0.11	0.30	0.06	0.22	0.15
10	----------	0.08	0.02	0.06	0.03	0.18	0.11	0.30	0.06	0.22	0.15
11	----------	0.04	0.02	0.01	0.04	0.17	0.15	0.37	0.28	0.15	0.13
12	----------	0.04	0.02	0.01	0.04	0.17	0.15	0.37	0.28	0.15	0.13
13	----------	0.04	0.02	0.01	0.02	0.17	0.15	0.37	0.28	0.15	0.13
14	----------	0.07	0.07	0.03	0.02	0.24	0.25	0.27	0.14	0.30	0.18
15	----------	0.07	0.07	0.03	0.02	0.24	0.25	0.27	0.14	0.30	0.18
16	----------	0.04	0.07	0.01	0.02	0.24	0.20	0.31	0.22	0.29	0.17
17	----------	0.04	0.07	0.01	0.03	0.24	0.20	0.31	0.22	0.29	0.17
18	0.02	0.08	0.05	0.03	0.03	0.16	0.07	0.38	0.19	0.26	0.13
19	0.02	0.08	0.05	0.03	0.03	0.16	0.07	0.38	0.19	0.26	0.13
20	0.02	0.08	0.05	0.03	0.03	0.16	0.07	0.38	0.19	0.26	0.13
21	0.05	0.09	0.07	0.01	0.06	0.16	0.14	0.28	0.25	0.26	0.14
22	0.05	0.09	0.07	0.01	----------	0.16	0.14	0.28	0.25	0.26	0.14
23	0.04	0.07	0.02	0.04	0.10	0.09	0.06	0.31	0.10	0.29	0.08
24	0.04	0.07	0.02	0.04	0.06	0.09	0.06	0.31	0.10	0.29	0.08
25	0.11	0.06	----------	0.01	0.03	0.09	0.11	0.38	0.20	0.22	0.14
26	0.11	0.06	0.06	0.01	0.08	0.09	0.11	0.38	0.20	0.22	0.14
27	0.11	0.06	----------	0.01	0.06	0.09	0.11	0.38	0.20	0.22	0.14
28	0.07	0.10	0.02	0.06	0.08	0.10	0.08	0.31	0.30	0.09	0.16
29	0.07	0.10	0.02	0.06	0.05	0.10	0.08	0.31	0.30	0.09	0.16
30	0.03	0.10	0.02	0.04	0.05	0.18	0.45	0.30	0.27	0.29	0.17
31	0.03	0.10	0.02	0.04	----------	0.18	0.45	0.30	0.27	0.29	0.17
Mean value	0.05	0.08	0.04	0.03	0.04	0.15	0.16	0.28	0.19	0.23	0.14

FIGURE 1.—PROFILE OF BETA ACTIVITY, AVERAGE MEASUREMENTS OF SURFACE AIR AT STATIONS NEAR THE 80th MERIDAN (WEST), FIRST QUARTER AND MARCH 1961



(1) Average based on one month.
(2) Average based on two months.

Atmospheric Levels of Fission Product Gross Beta Activity Collected In Italy

Division of Biology and Sanitary Protection
Italian National Committee for Nuclear Energy

The information listed in table 2 summarizes the results of atmospheric fission product gross beta measurements made at ground level throughout Italy during the third and fourth quarters of 1960. Figure 1 illustrates the approximate geographic locations of the sampling stations referred to in table 2, and table 1 presents their respective coordinates and elevations.

Table 2 was compiled from data that appeared in Report number B10/03/61 entitled, "Data on Environmental Radioactivity, Collected in Italy (July–December 1960)" issued February 1961.

Similar data for the last two quarters of 1959 and the first two quarters of 1960 appeared in *Radiological Health Data,* Volume II, Number 6.

TABLE 1.—GROUND LEVEL FISSION PRODUCT GROSS BETA SAMPLING STATIONS–COORDINATES AND ELEVATIONS, ITALY

Station	Longitude	Latitude	Elevation (meters)	Station	Longitude	Latitude	Elevation (meters)
Alghero	8° 17′ 02″ E	40° 38′ 11″ N	21	Monte Scuro	16° 23′ 50″ E	39° 19′ 50″ N	1710
Ancona	13° 30′ 53″ E	43° 37′ 22″ N	105	Monte Terminillo	12° 59′ 06″ E	42° 27′ 36″ N	1874
Bari	16° 52′ 13″ E	41° 07′ 08″ N	4	Napoli "A"	14° 15′ 13″ E	40° 50′ 10″ N	2
Bologna	11° 19′ 44″ E	44° 29′ 12″ N	64	Napoli "B"	14° 15′ 22″ E	40° 50′ 50″ N	22
Brindisi	17° 56′ 30″ E	40° 39′ 30″ N	8	Padova	11° 52′ 38″ E	45° 24′ 30″ N	14
Casaccia	12° 15′ 58″ E	42° 02′ 25″ N	154	Palermo	13° 20′ 56″ E	38° 06′ 19″ N	9
Cozzo Spadaro	15° 07′ 59″ E	36° 41′ 04″ N	40	Pian Rosa'	7° 42′ 22″ E	45° 56′ 06″ N	3488
Elmas	9° 03′ 15″ E	39° 15′ 15″ N	18	Resina	14° 23′ 36″ E	40° 49′ 37″ N	608
Ferrania	8° 19′ 01″ E	44° 21′ 18″ N	363	Roma	12° 11′ 08″ E	41° 49′ 38″ N	72
Garigliano Foce	13° 50′ 03″ E	41° 15′ 43″ N	8	Saluggia	8° 01′ 25″ E	45° 13′ 05″ N	170
Genova	8° 55′ 21″ E	44° 25′ 08″ N	[illegible]	S. Donato Milanese	....	....	....
Ispra	8° 37′ 35″ E	45° 48′ 11″ N	251	S. Giusto	10° 23′ 32″	43° 41′ 24″ N	5
Latina	12° 48′ 33″ E	41° 25′ 39″ N	6	S. Piero a Grado	10° 20′ 48″ E	43° 40′ 45″ N	3
Livorno	10° 18′ 29″ E	43° 31′ 35″ N	3	Sanremo	7° 49′ 45″ E	43° 49′ 12″ N	112
Messina	15° 33′ 13″ E	38° 12′ 00″ N	54	Tarvisio	13° 34′ 58″ E	46° 30′ 22″ N	777
Milano "A"	9° 11′ 27″ E	45° 27′ 59″ N	123	Trapani	12° 32′ 00″ E	37° 57′ 45″ N	71
Milano "B"	9° 11′ 27″ E	45° 27′ 59″ N	123	Trieste	13° 45′ 09″ E	45° 38′ 37″ N	8
Milano "C"	9° 11′ 27″ E	45° 27′ 59″ N	123	Verbania Pallanza	8° 33′ 06″ E	45° 55′ 25″ N	212
Monte Cimone	10° 41′ 55″ E	44° 11′ 35″ N	2173	Verona Villafranca	10° 53′ 24″ E	45° 23′ 37″ N	73
Monte Paganella	11° 02′ 13″ E	46° 08′ 35″ N	2125	Vigna di Valle	12° 13′ 00″ E	42° 04′ 45″ N	270
Monte S. Angelo	15° 56′ 53″ E	41° 42′ 28″ N	838				

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Figure 1.—SAMPLING STATIONS FOR THE DETERMINATION OF FISSION BETA RADIOACTIVITY IN AIR AT GROUND LEVEL

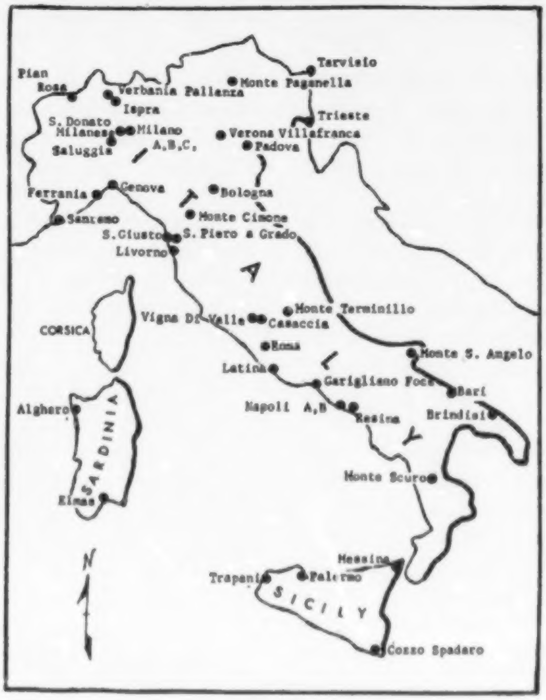

Table 2.—FISSION PRODUCT GROSS BETA ACTIVITY IN AIR AT GROUND LEVEL, 1960

[Average concentrations in $\mu\mu c/m^3$]

Station	Third quarter	Fourth quarter	Yearly average	Station	Third quarter	Fourth quarter	Yearly average
Alghero	0.09	<0.05	[3] <0.13	Monte Scuro	0.11	0.07	0.13
Ancona	[1] 0.08	0.05	[4] 0.60	Monte Terminillo	0.11	0.05	0.10
Bari	0.09	<0.04	[3] <0.09	Napoli "A"	0.10	<0.05	[3] <0.09
Bologna	0.11	<0.04	[3] <0.09	Napoli "B"	0.11	0.04	0.11
Brindisi	0.06	0.06	[6] 0.09	Padova	[9] 0.05	0.02	[6] 0.06
Casaccia	0.13	0.04	0.11	Palermo	0.10	<0.05	[3] <0.10
Cozzo Spadaro	0.08	<0.05	[3,5] <0.10	Pian Rosa'	0.10	0.06	0.18
Elmas	0.10	0.05	0.17	Resina	0.09	<0.04	[3] <0.09
Ferrania	0.03	0.02	0.04	Roma	0.08	0.04	[8] 0.07
Garigliano Foce	0.45	0.18	[5] 0.28	Saluggia	0.13	0.03	[5] 0.10
Genova	0.08	<0.04	[3] <0.13	S. Donato Milanese	------	------	[8] 0.07
Ispra	0.07	0.03	0.09	S. Giusto	0.08	0.04	0.07
Latina	0.42	0.14	[illegible]	S. Piero a Grado	0.08	0.05	0.08
Livorno	0.08	0.03	0.06	Sanremo	[1] 0.08	0.06	[4] 0.07
Messina	0.11	0.07	0.11	Tarvisio	0.08	0.06	[9] 0.07
Milano "A"	0.07	0.05	0.07	Trapani	0.08	0.05	0.09
Milano "B"	[2] 0.08	0.03	[6] 0.08	Trieste	0.08	<0.04	[3] <0.08
Milano "C"	0.11	0.05	0.10	Verbania Pallanza	0.08	<0.04	[3] <0.08
Monte Cimone	0.11	0.06	0.11	Verona Villafranca	0.09	0.06	[9] 0.08
Monte Paganella	------	0.06	[7] 0.06	Vigna di Valle	0.12	0.06	0.10
Monte S. Angelo	0.07	0.05	0.08				

[1] Based on measurements made in August and September.

[2] Based on measurements made in July and September.

[3] Indicates that at least one month's data was preceded by a less than sign (<). In these cases, the actual "less than value" was used for the purpose of computing both the quarterly and yearly averages.

[4] Based on measurements made in August through December.

[5] Based on measurements made in February through December

[6] Based on measurements made in January through July, and September through December.

[7] Based on measurements made in October through December.

[8] Based on measurements made in January through June.

[9] Based on measurements made in July through December.

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Canadian Radioactive Fallout Study Program

Department of National Health and Welfare,
Dominion of Canada

As part of its Radioactive Fallout Study Program, the Radiation Protection Division, Department of National Health and Welfare, Dominion of Canada, conducts air and precipitation sampling programs.

The nation-wide air sampling program is conducted for two main purposes: (1) to provide a convenient method for the early detection of changes in fission product concentration in air and therefore of likely changes in the deposition of fission products on the ground, and (2) to obtain data to show the day-to-day and station-to-station variations. This may be useful to meteorologists in a better understanding of the mechanisms involved in radioactive fallout distribution in the atmosphere.

A more detailed discussion of the sampling procedures, methods for analyses and interpretation of results of the Department's radioactive fallout program is contained in the "Annual Report for 1959," Report Number CNHW (RP-3).

Radiological Health Data, Volume II, Numbers 1 and 4 presented data on total beta activity in air and precipitation for the periods July 1959–June 1960 and the third quarter of 1960 respectively. With the permission of the Department of National Health and Welfare, Dominion of Canada, similar data are presented in tables 1, 2, and 3 for the fourth quarter of 1960.

TABLE 1.—TOTAL BETA RADIOACTIVITY IN AIR, FOURTH QUARTER 1960

[Average concentrations in dpm/m³]

Station locaion	October	November	December
Aklavik	0.10	0.18	0.19
Calgary	0.18	0.19	0.24
Chatham	0.15	0.15	0.19
Coral Harbour	0.11	0.18	0.21
Edmonton	0.17	0.22	0.24
Fort Churchill	0.07	0.19	0.18
Fort Williams	0.19	0.14	0.24
Fredericton	0.11	0.12	0.18
Kapuskasing	0.17	0.13	0.24
Montreal	0.19	0.16	0.23
Moosonee	0.15	0.16	0.26
Ottawa	0.20	0.20	0.23
Regina	0.17	0.26	0.28
Resolute	0.07	0.24	0.24
Saskatoon	0.17	0.19	0.26
Shearwater	0.17	0.16	0.22
Torbay	0.11	0.14	0.16
Toronto	0.19	0.19	0.25
Vancouver	0.12	0.11	0.14
Whitehorse	0.13	0.19	0.14
Windsor	0.27	0.23	0.25
Winnipeg	0.18	0.20	0.30
Yellowknife	0.11	0.23	0.24

TABLE 2.—MONTHLY AVERAGE FISSION PRODUCT CONCENTRATION IN AIR, FOURTH QUARTER 1960

[Average concentrations in dpm/m³]

Month	Number of stations operating 50% of the time	Minimum average all stations	Maximum average all stations	Overall average
October	22	0.07	0.27	0.15
November	22	0.11	0.24	0.18
December	22	0.14	0.30	0.22

TABLE 3.—TOTAL BETA RADIOACTIVITY IN PRECIPITATION, FOURTH QUARTER 1960

Station location	October		November		December	
	μμc/liter	inches	μμc/liter	inches	μμc/liter	inches
Aklavik	9.1	1.49	4.6	3.80	6.1	3.90
Calgary	31.9	0.78	54.7	0.50	31.9	0.69
Chatham	10.6	3.55	12.2	4.26	10.7	4.38
Coral Harbour	42.6	0.85	1.5	1.31	242.2	0.52
Edmonton	27.4	1.66	47.1	0.60	22.8	1.06
Fredericton	22.8	3.41	12.1	5.34	15.2	3.91
Fort Churchill	21.3	2.26	18.2	2.18	47.1	0.75
Fort Williams	25.8	3.18	24.4	2.00	74.5	0.41
Goose Bay	13.7	2.82	13.7	1.84	12.2	2.02
Kapuskasing	18.2	2.93	12.2	3.51	12.2	1.80
Montreal	10.6	4.54	24.4	3.46	9.1	4.7[illegible]
Moosonee	7.6	2.67	6.1	4.68	24.[illegible]	1.28
Ottawa	13.7	2.95	21.3	2.17	28.9	1.63
Regina	----------	trace	3.0	0.54	98.8	0.31
Resolute	----------	NS[1]	----------	NS	----------	NS
Saskatoon	63.8	0.24	53.2	0.43	85.1	0.54
Shearwater	35.0	2.20	36.5	2.17	16.7	3.18
Torbay	6.1	7.21	7.6	5.16	10.6	5.23
Toronto	38.0	2.40	22.8	2.91	74.5	0.77
Vancouver	12.1	8.20	15.2	5.55	9.1	5.42
Whitehorse	48.6	0.98	173.3	0.43	19.8	0.47
Windsor	35.0	1.61	28.[illegible]	1.17	18.3	0.71
Winnipeg	22.8	1.84	123.6	0.48	10.6	0.75
Yellowknife	16.7	2.59	13.7	1.8[illegible]	10.6	0.72
Average	24.2	--------	31.8	--------	40.1	--------

[1] NS—No sample.

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SECTION II. — FOOD, OTHER THAN MILK

Survey of Radioactivity In Food

Food and Drug Administration

The Food and Drug Administration conducts a continuing surveillance to determine the concentrations of certain radionuclides in a variety of different food items, domestic and foreign. *Radiological Health Data,* Volume II, Number 1 presented data on the gross beta radioactivity in foods. Table 1 presents some partial results on bulk food commodities collected from 12 major growing areas, table 2, the preliminary results of a survey of baby foods, and table 3, some results on spot checking of fruits and vegetables and other items. These samples were collected by representatives of Food and Drug Administration Districts.

TABLE 1.—RADIOANALYSES OF SELECTED RAW AGRICULTURAL PRODUCTS HARVESTED IN 1960

[Concentrations in $\mu\mu c$/kg original material]

Raw agricultural product	Area		Strontium-90	Cesium-137
	County	State		
Cabbage	Fannin	Ga.	25	<5
Potatoes	Fannin	Ga.	6	291
Wheat	Barton	Ga.	17	25
Potatoes	Accomack	Va.	3	<6
Wheat	Accomack	Va.	46	120
Cabbage	Clinton	Ohio	13	80
Potatoes	Clinton	Ohio	3	<6
Wheat	Clinton	Ohio	50	24
Wheat	Clinton	Ohio	50	20
Wheat	Taylor & Callahan	Texas	7	25
Wheat	Placer & Sacramento	Calif.	7	----------
Potatoes	San Joaquin	Calif.	0.4	----------
Wheat	Johnson	Kansas	18	----------
Wheat	Walla Walla	Wash.	3	----------

TABLE 2.—RADIOANALYSES FOR STRONTIUM-90 IN SELECTED BABY FOODS

[Concentration in $\mu\mu c$/kg original material]

Product	Place grown or processed	Date harvested or processed	Strontium-90
Strained peaches	Stanislaus, Calif.	1960	0.1
Strained peaches	Calif.[1]	1960	0.2
Strained peaches	Berrien, Mich.	Aug. 1960	1.2
Strained plums	Calif.[1]	Sept. 1960	0.7
Strained pears	Berrien, Mich.	Aug. 29, 1960	3.9
Strained apricots w/tapioca.	Contra Costa, Calif.	June 1960	0.2
Strained creamed spinach.	Muskegan, Mich.	May 1, 1960	11.0
Strained peas	Saginaw & Mecasta, Mich.	July 19, 1960	3.8
Strained squash	Henderson, N.C.	Aug. 15, 1960	18.0
Beef & b. broth	St. Paul, Minn.[1]	Apr. 13, 1960	1.4
Veal & v. broth	St. Paul, Minn.[1]	Apr. 7, 1960	0.8
Oat flour	Cedar Rapids, Iowa[1]	July 1960	11.0
Soya flour	Chicago, Ill.[1]	July 1960	25.0
Wheat germ	Minneapolis, Minn.[1]	July 1960	46.0

[1] Denotes processing location and date.

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TABLE 3.—RADIOANALYSES FOR STRONTIUM-90 IN FRUITS, VEGETABLES AND MISCELLANEOUS ITEMS

[Concentrations in $\mu\mu c$/kg original material]

Product	Area		Date harvested or processed	Strontium-90
	County	State or country		
Fresh tomatoes	Morgan	W.Va.	Sept. 1, 1960	2.6
Fresh tomatoes	Roanoke	Va.	Aug. 31, 1960	1.9
Fresh tomatoes	Miami	Ohio	Sept. 8, 1960	9.9
Fresh tomatoes	Wicomico	Md.	Sept. 1, 1960	2.0
Fresh tomatoes	Northumberland	Va.	Aug. 25, 1960	2.8
Fresh tomatoes	Westmorland	Va.	Aug. 25, 1960	3.4
Canned tomatoes	Roanoke	Va.	Aug. 31, 1960	1.5
Fresh peaches	Rappahanock	Va.	Aug. 20, 1960	1.6
Canned peaches	Rappahanock	Va.	Aug. 20, 1960	0.9
Dried peaches	Santa Clara	Calif.	1960	3.2
Fresh wax beans	Dorchester	Md.	Sept. 7, 1960	7.2
Canned green beans	Erie	N.Y.	Sept. 12, 1960	2.4
Lettuce	Steuben	N.Y.	Sept. 13, 1960	2.6
Asparagus		N.J.	1960	10.0
Canned tuna fish		Japan	1959?	0.1
Canned tuna fish		Japan	1960?	0.3
Cheddar cheese	Erie	N.Y.	Sept. 13, 1960	43.0
Lawn grass (6 lbs collected from area 15′ × 60′).	Montgomery	Md.	July 18, 1960	145.0

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SECTION III. — MILK

Milk Monitoring Program

Division of Radiological Health, Public Health Service

There are two Public Health Service Milk Monitoring Programs. The original network consisted of five milkshed sampling stations. It was later expanded to twelve stations, nine of which are still active. Raw milk is spot sampled at these stations. During 1960 a processed milk sampling program of 60 stations was established. Since the sampling procedures for the raw milk sampling stations and the processed milk area sampling stations are different, they are described and reported separately. The Public Health Service Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, continues to conduct the analyses for the original network stations; the Public Health Service Southeastern Radiological Health Laboratory at Montgomery, Alabama, and the Southwestern Radiological Health Laboratory at Las Vegas, Nevada, provide analytical services for the new program.

The purposes of the two sampling programs are not the same. The original network was established to develop sampling and radiochemical analytical proficiencies under conditions which would remain similar over a period of time in regard to the source of milk. During the operation of this program it became apparent that a broader sampling program, more directly related to the milk consumed by the population, was necessary. The Public Health Service, Department of Health, Education, and Welfare, acted to provide facilities for this change. This resulted in the transition from the program of sampling raw milk, collected from milksheds of limited size, to a sampling program designed to be representative of the processed milk consumed in a given municipality.

In some instances, the newly designated stations are the same as those which were reported originally. The establishment of the new processed milk area sampling stations does not preclude the need for further raw milk sampling from the selected milkshed serving the same city. It is important that both networks be in operation for a sufficient period of time to provide an overlap for the purpose of comparative study.

Because of the different sources of these samples, changes in the method of collecting samples, and the utilization of different laboratory techniques, differences were anticipated in the amounts of radioactivity found in the milk under the two programs. For this reason, an investigation to determine the comparability of the two programs was begun in January 1961. This investigation covers many factors including laboratory methodology and collection methods. Until this study has been completed and additional experience has been gained under the new program, no valid interpretation can be made of any differences of radioactivity in milk samples collected under the two systems.

Publication of the data from each program will normally follow about four months after sample collection because of the time required for shipment, processing, decay product buildup, compilation of the data, and clearance and publication procedures.

Raw Milk Sampling Stations

The initial purpose of establishing this network was in keeping with the normal and continuing program of the Public Health Service to determine trends in our changing environment with respect to measuring the amounts of radioactivity in water, air, milk, and other foods. Milk was the food chosen for initial testing because it is among the most important components of the diet and is available at all seasons of the year and in all climates. A primary objective of the project was to develop effective collection systems and radiochemical analysis procedures which would make them more suitable for larger scale programs.

The criteria on which the selection of the original sampling stations was based appeared in the discussion sections of all Volume I issues of *Radiological Health Data.*

One-gallon raw milk samples are collected from a dairy company once each month and forwarded by air parcel post to the Robert A. Taft Sanitary Engineering Center for radionuclide analyses. These samples represent between 2,000- and 90,000-gallon lots. The concentration of iodine-131, barium-140, and cesium-137 are currently being measured by gamma scintillation spectroscopy. Total radiostrontium and strontium-90 are determined following radiochemical separations. The amount of strontium-90 is calculated by measuring the buildup of the strontium-90 daughter decay product, yttrium-90, over a two-week period. Measurements are made in a low background anticoincidence beta counter. The total radioactive strontium is counted in a shielded internal proportional counter. The difference between the total strontium and strontium-90 is reported as strontium-89. Stable calcium is also determined.

The April through September 1960 issues of *Radiological Health Data* list references for technical descriptions of analytical procedures.

Tables 1 through 6 present quarterly averages for each radioisotope and stable calcium for 1957–1960, and the first quarter of 1961. Data for March 1961 are also included.

Processed Milk Area Sampling Stations

The processed milk surveillance program will provide additional information on levels of radioactivity in milk consumed by the public. The new stations have been established in cooperation with State and local health and milk sanitation agencies. Each city has been selected to provide adequate coverage with respect to production areas and the consuming population. The emphases on this expanded sampling and radioassay program are:

1. to measure the levels of radioactivity of the milk consumed by the public in various regions of the country by obtaining samples of pasteurized and homogenized milk at the processing plant, and
2. to provide one sampling point within each State with additional points when indicated by widely varying conditions of the milk supply or the need to provide coverage of large population groups.

The new network was designed to sample processed milk rather than the raw product. The sampling procedure was developed to provide a sample from one day's sales per month in a community which would be as representative of the total supply as can be achieved under practical conditions. Each sample is a composite of those plants supplying not less than 90 percent of a city's milk supply. The contribution from each plant to the total sample is approximately proportional to the volume of milk sold.

The samples from the new stations are collected with the assistance of the various State and local health and milk sanitation agencies and are shipped for analyses to either the Southwestern or Southeastern Radiological Health Laboratory. The Southeastern Radiological Health Laboratory processes samples from the 30 states generally east of the Mississippi, and the Southwestern Radiological Health Laboratory processes samples from the western states. Figure 1 shows the locations of these stations.

At the present time radioassays for Sr^{90}, Cs^{137}, Sr^{89}, Ba^{140} and I^{131} are being performed. The latter three radionuclides are not presently found in milk by the current methods of detection. The lower level of detection for Sr^{89} is 5 μμc/liter, and Ba^{140} and I^{131}, 10 μμc/liter. Other radionuclides of concern to public health agencies will be included for assay as necessary for a more complete monitoring of the milk supply.

Tables 7, 8, and 9 present quarterly averages for strontium-90, cesium-137, and stable calcium, respectively, for 1960 and the first quarter of 1961. Data for March 1961 are also included.

TABLE 1.—TABULATION OF RESULTS, STRONTIUM-90 DETERMINATIONS, RAW MILK SAMPLING STATIONS, 1957–1961

[Concentrations in μμc/liter]

Area	1957			1958				1959				1960				1961	
	2nd qtr	3rd qtr	4th qtr	1st qtr	2nd qtr	3rd qtr	4th qtr	1st qtr	2nd qtr	3rd qtr	4th qtr	1st qtr	2nd qtr	3rd qtr	4th qtr	1st qtr	March
Atlanta, Ga.	------	------	------	------	14	12	10	12	21	15	14	17	16	13	12	13	11
Austin, Tex.	------	------	------	------	2	4	3	6	7	4	5	6	4	3	4	4	4
Chicago, Ill.	------	------	------	------	------	8	7	6	11	9	9	9	12	8	8	6	8
Cincinnati, O.	[2] 6	5	7	4	9	10	11	12	17	10	12	12	11	9	8	8	8
Fargo, N.D.—Moorehead, Minn.	------	------	------	------	[1] 15	14	13	12	16	15	14	[1] 11	------	------	------	------	------
New York, N.Y.	[2] 5	7	5	5	6	6	9	7	11	10	9	10	11	9	8	9	7
Overton, Nev.	------	------	------	------	------	------	------	[1] 4	4	2	3	4	3	[1] 2	------	------	------
Sacramento, Calif.	[2] 6	2	5	5	7	5	4	5	7	3	5	3	4	4	2	5	3
Salt Lake City, Utah	[2] 6	4	4	3	5	5	5	4	9	7	6	8	8	5	4	4	2
Spokane, Wash.	------	------	------	------	------	[2] 8	10	9	18	10	12	13	16	9	7	7	8
St. George, Utah	------	------	------	------	------	------	------	[1] 6	6	[2] 3	3	4	------	------	------	------	------
St. Louis, Mo.	[2] 12	8	9	8	12	16	16	20	28	17	24	20	22	16	14	13	13
Network average	7	5	6	5	9	9	9	9	13	9	10	10	11	8	8	8	7

[1] Average based on one month.
[2] Average based on two months.

TABLE 2.—TABULATION OF RESULTS, STRONTIUM-89 DETERMINATIONS, RAW MILK SAMPLING STATIONS 1957–1961

[Concentrations in μμc/liter]

Area	1957			1958				1959				1960				1961	
	2nd qtr	3rd qtr	4th qtr	1st qtr	2nd qtr	3rd qtr	4th qtr	1st qtr	2nd qtr	3rd qtr	4th qtr	1st qtr	2nd qtr	3rd qtr	4th qtr	1st qtr	March
Atlanta, Ga.	------	------	------	------	[1] 35	75	45	75	90	15	<5	<5	<5	<5	<5	<5	<5
Austin, Tex.	------	------	------	------	[1] 25	30	40	45	45	5	<5	<5	<5	<5	<5	<5	<5
Chicago, Ill.	------	------	------	------	------	70	45	<5	30	10	<5	<5	<5	<5	<5	<5	<5
Cincinnati, O.	------	[2] 75	65	<5	65	130	65	20	40	10	<5	<5	<5	<5	<5	<5	<5
Fargo, N.D.—Moorehead, Minn.	------	------	------	------	[1] 80	110	80	20	25	20	<5	[1] <5	------	------	------	------	------
New York, N.Y.	------	[2] 80	55	<5	30	65	50	5	20	10	<5	<5	<5	<5	<5	<5	<5
Overton, Nev.	------	------	------	------	------	------	------	[1] 5	<5	<5	<5	<5	<5	[1] <5	------	------	------
Sacramento, Calif.	------	[1] 20	15	5	50	20	15	30	25	<5	<5	<5	<5	<5	<5	<5	<5
Salt Lake City, Utah	------	[2] 65	45	5	30	40	15	5	20	5	<5	<5	<5	<5	<5	<5	<5
Spokane, Wash.	------	------	------	------	------	[2] 55	35	15	50	20	<5	<5	<5	<5	<5	<5	<5
St. George, Utah	------	------	------	------	------	------	------	[1] <5	15	[2] <5	<5	<5	------	------	------	------	------
St. Louis, Mo.	------	[2] 160	80	20	90	285	130	95	125	15	5	<5	<5	<5	<5	<5	<5
Network average	------	80	50	5	50	90	50	30	40	10	<5	<5	<5	<5	<5	<5	<5

[1] Average based on one month.
[2] Average based on two months.

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TABLE 3.—TABULATION OF RESULTS, CESIUM-137 DETERMINATIONS, RAW MILK SAMPLING STATIONS, 1957–1961

[Concentrations in μμc/liter]

Area	1957			1958				1959				1960				1961	
	2nd qtr	3rd qtr	4th qtr	1st qtr	2nd qtr	3rd qtr	4th qtr	1st qtr	2nd qtr	3rd qtr	4th qtr	1st qtr	2nd qtr	3rd qtr	4th qtr	1st qtr	March
Atlanta, Ga	------	------	------	------	[1] 120	100	70	85	120	90	45	60	45	25	15	25	30
Austin, Tex	------	------	------	------	[1] 70	50	40	50	65	50	20	30	20	10	5	10	15
Chicago, Ill	------	------	------		------	90	65	65	70	60	35	40	40	20	15	20	20
Cincinnati, O	[2] 30	45	40	55	60	80	60	60	70	40	30	40	20	15	15	15	25
Fargo, N.D.—Moorehead, Minn	------	------	------	------	[1] 110	120	65	65	75	65	45	[1] 45	------	------	------	------	------
New York, N.Y	[1] 35	45	45	40	50	80	60	65	65	55	30	45	35	10	15	20	20
Overton, Nev	------	------	------	------	------	------	------	[1] 30	35	40	15	20	10	[1] 10	------	------	------
Sacramento, Calif	[2] 35	55	40	45	80	65	45	45	60	55	15	15	10	5	10	10	20
Salt Lake City, Utah	[2] 40	50	45	60	55	45	35	35	50	40	35	45	40	15	10	10	20
Spokane, Wash	------	------	------	------	------	[2] 85	75	75	85	60	60	35	45	25	20	15	20
St. George, Utah	------	------	------	------	------	------	------	35	45	[2] 30	15	20	------	------	------	------	------
St. Louis, Mo	[1] 45	55	50	45	85	125	75	80	120	80	40	40	35	20	20	25	30
Network average	35	50	45	50	80	85	60	60	70	60	30	40	30	15	15	15	20

[1] Average based on one month.
[2] Average based on two months.

TABLE 4.—TABULATION OF RESULTS, IODINE-131 DETERMINATIONS, RAW MILK SAMPLING STATIONS, 1957–1961

[Concentrations in μμc/liter]

Area	1957			1958				1959				1960				1961	
	2nd qtr	3rd qtr	4th qtr	1st qtr	2nd qtr	3rd qtr	4th qtr	1st qtr	2nd qtr	3rd qtr	4th qtr	1st qtr	2nd qtr	3rd qtr	4th qtr	1st qtr	March
Atlanta, Ga	------	------	------	------	[1] <10	40	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Austin, Tex	------	------	------	------	[1] <10	30	80	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Chicago, Ill	------	------	------	------	------	60	30	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cincinnati, O	[1] 370	[2] 330	110	<10	10	50	70	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Fargo, N.D.—Moorhead, Minn	------	------	------	------	[1] <10	60	40	<10	<10	<10	<10	[1] <10	------	------	------	------	------
New York, N.Y	[1] 40	[2] 175	175	<10	30	50	40	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Overton, Nev	------	------	------	------	------	------	------	[1] <10	<10	<10	<10	<10	<10	[1] <10	------	------	------
Sacramento, Calif	[1] 250	[2] <10	<10	<10	80	30	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Salt Lake City, Utah	[1] 440	[2] 470	350	10	10	80	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Spokane, Wash	------	------	------	------	------	[2] 40	35	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
St. George, Utah	------	------	------	------	------	------	------	[1] <10	[2] <10	<10	<10	<10	------	------	------	------	------
St. Louis, Mo	[1] 410	[2] 590	290	<10	30	235	60	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Network average	300	310	185	<10	35	85	40	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

[1] Average based on one month.
[2] Average based on two months.

TABLE 5.—TABULATION OF RESULTS, BARIUM-140 DETERMINATIONS, RAW MILK SAMPLING STATIONS, 1957–1961

[Concentrations in μμc/liter]

Area	1957			1958				1959				1960				1961	
	2nd qtr	3rd qtr	4th qtr	1st qtr	2nd qtr	3rd qtr	4th qtr	1st qtr	2nd qtr	3rd qtr	4th qtr	1st qtr	2nd qtr	3rd qtr	4th qtr	1st qtr	March
Atlanta, Ga	------	------	------	------	[1] <10	20	<10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10
Austin, Tex	------	------	------	------	[1] <10	<10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Chicago, Ill	------	------	------	------	------	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cincinnati, O	------	[2] 110	30	<10	20	70	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Fargo, N.D.—Moorehead, Minn	------	------	------	------	[1] 20	40	20	<10	<10	<10	<10	[1] <10	------	------	------	------	------
New York, N.Y	------	[2] 100	50	<10	<10	30	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Overton, Nev	------	------	------	------	------	------	------	[1] <10	<10	<10	<10	<10	<10	[1] <10	------	------	------
Sacramento, Calif	------	20	40	<10	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Salt Lake City, Utah	[1] 70	110	50	<10	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Spokane, Wash	------	------	------	------	------	[2] 10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
St. George, Utah	------	------	------	------	------	------	------	[1] <10	<10	[2] <10	<10	<10	------	------	------	------	------
St. Louis, Mo	[1] 90	240	50	<10	40	130	30	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Network average	80	120	40	<10	10	35	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

[1] Average based on one month.
[2] Average based on two months.

TABLE 6.—TABULATION OF RESULTS, STABLE CALCIUM DETERMINATIONS, RAW MILK SAMPLING STATIONS, 1957–1961

[Concentrations in $\mu\mu c$/liter]

Area	1957			1958				1959				1960				1961	
	2nd qtr	3rd qtr	4th qtr	1st qtr	2nd qtr	3rd qtr	4th qtr	1st qtr	2nd qtr	3rd qtr	4th qtr	1st qtr	2nd qtr	3rd qtr	4th qtr	1st qtr	March
Atlanta, Ga	------	------	------	------	[1] 1.16	1.17	1.21	1.24	1.23	1.14	1.11	1.16	1.10	1.09	1.19	1.18	1.15
Austin, Tex	------	------	------	------	[1] 1.12	1.14	1.17	1.18	1.04	1.08	1.09	1.14	1.06	1.06	1.17	1.16	1.12
Chicago, Ill	------	------	------	------	------	1.11	1.12	1.11	1.14	1.06	1.09	1.08	1.12	1.05	1.15	1.17	1.15
Cincinnati, O	[2] 1.15	1.15	1.19	1.14	1.18	1.11	1.16	1.15	1.16	1.11	1.12	1.08	1.19	1.04	1.22	1.21	1.18
Fargo, N.D.—Moorehead, Minn	------	------	------	------	[1] 1.11	1.13	1.18	1.13	1.15	1.11	1.08	[1] 1.22	------	------	------	------	------
New York, N.Y	[2] 1.03	1.04	1.11	1.09	1.07	1.11	1.12	1.00	1.13	1.03	1.06	1.07	1.12	1.05	1.15	1.11	1.11
Overton, Nev	------	------	------	------	------	------	------	[1] 1.10	1.08	1.04	1.09	1.09	1.11	[1] 0.98	------	------	------
Sacramento, Calif	[2] 1.11	1.10	1.15	1.15	1.14	1.11	1.13	1.15	1.14	1.08	1.09	1.09	1.12	1.09	1.21	1.19	1.19
Salt Lake City, Utah	[2] 1.12	1.12	1.17	1.14	1.13	1.13	1.17	1.16	1.12	1.08	1.11	1.11	1.09	1.05	1.20	1.19	1.23
Spokane, Wash	------	------	------	------	------	[2] 1.17	1.22	1.23	1.17	1.16	1.12	1.15	1.07	1.09	1.21	1.22	1.18
St. George, Utah	------	------	------	------	------	------	------	[1] 1.16	1.12	[2] 1.06	1.08	1.08	------	------	------	------	------
St. Louis, Mo	[2] 1.20	1.20	1.29	1.30	1.24	1.25	1.28	1.28	1.27	1.19	1.27	1.30	11.7	1.11	1.29	1.26	1.24
Network average	1.12	1.12	1.18	1.16	1.15	1.14	1.18	1.17	1.15	1.10	1.11	1.13	1.12	1.05	1.20	1.19	1.17

[1] Average based on one month.
[2] Average based on two months.

FIGURE 1.—PROCESSED MILK AREA SAMPLING STATIONS

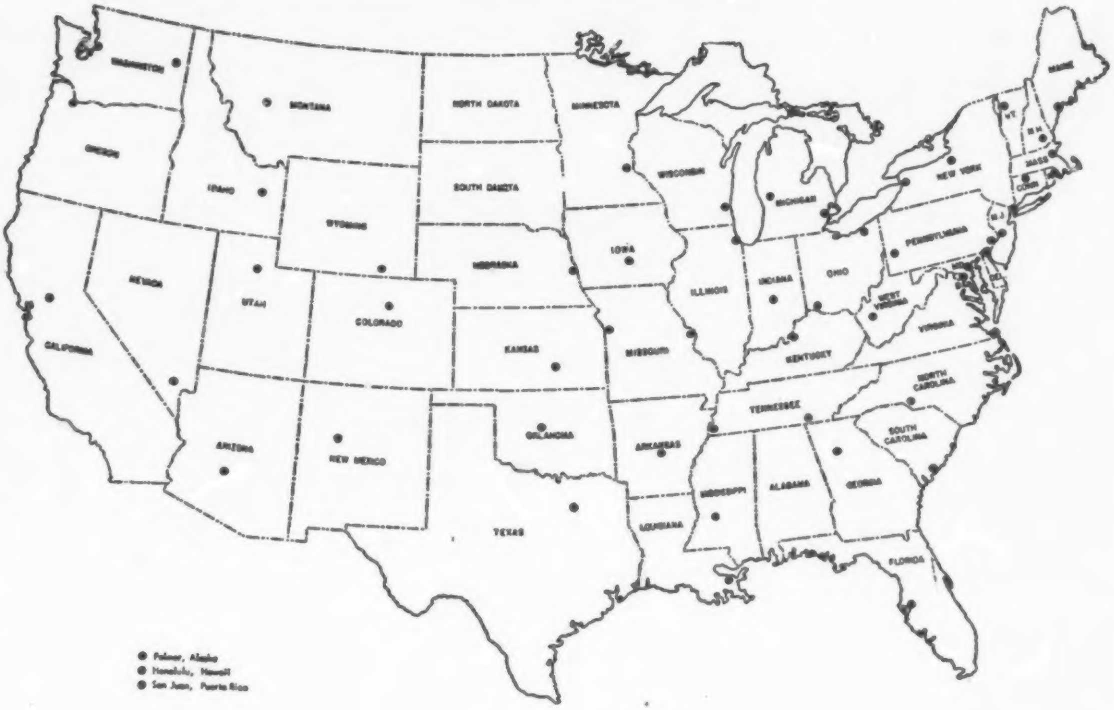

TABLE 7.—SUMMARY OF RESULTS, STRONTIUM-90 DETERMINATIONS, PROCESSED MILK AREA SAMPLING STATIONS, 1960–1961

[Average concentrations in μμc/liter]

Area	1960				1961	
	First quarter	Second quarter	Third quarter	Fourth quarter	First quarter	March
Albuquerque, N.Mex	[1] 3	5	4	4	5	4
Atlanta, Ga	--------	--------	[1] 11	9	7	6
Austin, Tex	--------	[1] 7	2	[2] 2	2	2
Baltimore, Md	--------	--------	[2] 7	5	6	6
Boston, Mass	--------	[1] 16	12	10	8	7
Buffalo, N.Y	--------	6	7	18	[2] 6	([3])
Burlington, Vt	--------	10	9	7	9	8
Charleston, S.C	--------	--------	[2] 10	11	8	10
Charleston, W.Va	--------	9	10	8	5	6
Charlotte, N.C	--------	[1] 14	12	11	9	8
Chattanooga, Tenn	--------	--------	[1] 11	10	8	6
Chicago, Ill	--------	--------	7	5	[2] 6	([3])
Cincinnati, Ohio	--------	--------	9	7	7	7
Cleveland, Ohio	--------	--------	8	7	6	6
Dallas, Tex	--------	[1] 8	6	6	5	6
Denver, Colo	[1] 8	8	5	7	6	8
Des Moines, Iowa	--------	[1] 8	7	[2] 8	7	8
Detroit, Mich	--------	--------	7	7	6	6
Grand Rapids, Mich	--------	--------	8	7	7	6
Hartford, Conn	--------	9	8	9	7	8
Helena, Mont	--------	[1] 9	6	6	4	2
Honolulu, Hawaii	--------	3	6	4	4	3
Idaho Falls, Idaho	[1] 4	7	5	5	5	5
Indianapolis, Ind	--------	--------	6	6	7	8
Jackson, Miss	--------	--------	[2] 12	11	10	8
Kansas City, Mo	--------	8	7	8	7	7
Laramie, Wyo	--------	6	5	5	5	6
Las Vegas, Nev	[1] 3	3	2	3	3	5
Little Rock, Ark	--------	--------	[2] 13	[2] 13	13	14
Louisville, Ky	--------	7	10	9	7	6
Manchester, N.H	--------	13	11	9	8	8
Memphis, Tenn	--------	--------	[1] 14	9	8	10
Milwaukee, Wis	--------	--------	6	6	5	5
Minneapolis, Minn	--------	--------	[2] 9	8	7	9
New Orleans, La	--------	--------	16	11	8	8
New York, N.Y	--------	[1] 11	9	8	[2] 7	8
Norfolk, Va	--------	--------	9	9	[2] 7	([3])
Oklahoma City, Okla	--------	--------	8	7	5	4
Omaha, Nebr	--------	--------	[2] 8	6	7	9
Palmer, Alaska	[1] 5	8	7	7	6	7
Philadelphia, Pa	--------	10	9	6	7	7
Phoenix, Ariz	--------	--------	4	4	2	2
Pittsburgh, Pa	--------	15	11	11	9	10
Portland, Me	--------	[1] 15	11	9	[1] 10	([3])
Portland, Oreg	--------	11	10	9	8	9
Providence, R.I	--------	[1] 18	11	9	9	9
Sacramento, Calif	--------	--------	[2] 5	5	3	4
Salt Lake City, Utah	[1] 8	7	4	5	4	5
San Francisco, Calif	--------	[1] 8	3	4	3	4
San Juan, P.R	--------	--------	4	4	3	2
Seattle, Wash	--------	9	8	6	7	7
Spokane, Wash	--------	10	6	6	[illegible]	7
St. Louis, Mo	--------	--------	[2] 7	8	7	8
Syracuse, N.Y	--------	7	7	7	6	6
Tampa, Fla	--------	--------	5	6	5	5
Trenton, N.J	--------	[1] 10	7	8	7	9
Washington, D.C	--------	--------	8	8	6	6
Wichita, Kans	--------	7	6	5	5	7
Wilmington, Del	--------	[1] 10	8	8	7	6
Network average	--------	9	8	8	6	7

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[1] Average based on one month.
[2] Average based on two months.
[3] Sample lost.

TABLE 8.—SUMMARY OF RESULTS, CESIUM-137 DETERMINATIONS, PROCESSED MILK AREA SAMPLING STATIONS, 1960–1961

[Average concentrations in μμc/liter]

Area	1960				1961	
	First quarter	Second quarter	Third quarter	Fourth quarter	First quarter	March
Albuquerque, N.Mex	--------	--------	--------	5	<5	<5
Atlanta, Ga	--------	--------	[2] <5	<5	5	<5
Austin, Tex	--------	[1] 20	<5	[2] <5	<5	<5
Baltimore, Md	--------	--------	[2] <5	<5	5	10
Boston, Mass	--------	[1] 30	15	<5	10	10
Buffalo, N.Y	--------	[1] 10	<5	<5	[2] <5	([3])
Burlington, Vt	--------	15	5	<5	5	10
Charleston, S.C	--------	--------	[2] 10	<5	5	<5
Charleston, W.Va	--------	<5	<5	<5	<5	<5
Charlotte, N.C	--------	[1] 20	<5	<5	<5	<5
Chattanooga, Tenn	--------	--------	<5	<5	<5	<5
Chicago, Ill	--------	--------	<5	<5	[2] <5	([3])
Cincinnati, Ohio	--------	--------	[2] <5	<5	<5	<5
Cleveland, Ohio	--------	--------	<5	<5	<5	<5
Dallas, Tex	--------	[1] <5	<5	<5	<5	<5
Denver, Colo	--------	--------	--------	10	5	10
Des Moines, Iowa	--------	--------	[1] 20	[2] 15	<5	<5
Detroit, Mich	--------	--------	<5	<5	<5	<5
Grand Rapids, Mich	--------	--------	<5	10	<5	<5
Hartford, Conn	--------	20	10	<5	10	10
Helena, Mont	--------	--------	[1] 25	5	<5	<5
Honolulu, Hawaii	--------	[1] 40	[1] 40	10	<5	<5
Idaho Falls, Idaho	--------	[1] 40	--------	10	<5	<5
Indianapolis, Ind	--------	--------	<5	<5	<5	<5
Jackson, Miss	--------	--------	[2] <5	<5	<5	<5
Kansas City, Mo	--------	--------	--------	10	<5	<5
Laramie, Wyo	--------	--------	--------	10	<5	<5
Las Vegas, Nev	--------	--------	--------	<5	<5	<5
Little Rock, Ark	--------	--------	[2] <5	[2] <5	5	10
Louisville, Ky	--------	<5	5	<5	<5	<5
Manchester, N.H	--------	45	25	15	15	20
Memphis, Tenn	--------	--------	[1] <5	<5	<5	<5
Milwaukee, Wis	--------	--------	<5	<5	<5	<5
Minneapolis, Minn	--------	--------	--------	<5	<5	<5
New Orleans, La	--------	--------	5	<5	10	15
New York, N.Y	--------	[1] 20	5	<5	[2] 5	10
Norfolk, Va	--------	--------	<5	<5	[2] <5	([3])
Oklahoma City, Okla	--------	--------	<5	<5	<5	<5
Omaha, Nebr	--------	--------	--------	5	5	<5
Palmer, Alaska	--------	--------	[1] 30	<5	<5	<5
Philadelphia, Pa	--------	[1] 30	5	<5	<5	<5
Phoenix, Ariz	--------	--------	[1] 15	15	<5	<5
Pittsburgh, Pa	--------	15	5	<5	<5	5
Portland, Me	--------	[1] 40	20	5	[2] 10	([3])
Portland, Oreg	--------	--------	70	20	10	10
Providence, R.I	--------	[1] 20	10	<5	10	10
Sacramento, Calif	--------	--------	--------	<5	<5	<5
Salt Lake City, Utah	--------	--------	--------	5	5	5
San Francisco, Calif	--------	--------	[1] 20	5	<5	<5
San Juan, P.R	--------	--------	<5	<5	<5	<5
Seattle, Wash	--------	--------	[1] 60	20	10	<5
Spokane, Wash	--------	--------	--------	20	5	<5
St. Louis, Mo	--------	--------	--------	35	10	10
Syracuse, N.Y	--------	15	10	<5	<5	<5
Tampa, Fla	--------	--------	[2] 85	70	35	40
Trenton, N.J	--------	[1] 20	<5	<5	<5	<5
Washington, D.C	--------	--------	5	<5	<5	<5
Wichita, Kans	--------	--------	--------	<5	<5	<5
Wilmington, Del	--------	[1] 40	<5	<5	<5	<5
Network average	--------	--------	10	5	<5	15

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[1] Average based on one month.
[2] Average based on two months.
[3] Sample lost.

TABLE 9.—SUMMARY OF RESULTS, CALCIUM DETERMINATIONS, PROCESSED MILK AREA SAMPLING STATIONS, 1960–1961

[Average concentrations in μμc/liter]

Area	1960				1961	
	First quarter	Second quarter	Third quarter	Fourth quarter	First quarter	March
Albuquerque, N.Mex	[1] 1.20	1.12	1.04	1.06	1.05	0.99
Atlanta, Ga	--------	--------	[2] 1.24	1.24	1.21	1.16
Austin, Tex	--------	[1] 1.16	1.09	[2] 1.27	1.26	1.28
Baltimore, Md	--------	--------	[2] 1.08	1.22	1.28	1.22
Boston, Mass	--------	[1] 1.31	1.13	1.22	1.27	1.29
Buffalo, N.Y	--------	[1] 1.41	1.12	1.16	[2] 1.18	([3])
Burlington, Vt	--------	1.22	1.15	1.22	1.23	1.22
Charleston, S.C	--------	--------	[2] 1.22	1.30	1.35	1.38
Charleston, W.Va	--------	1.21	[2] 1.08	1.23	1.21	1.19
Charlotte, N.C	--------	[2] 1.07	1.23	1.29	1.28	1.28
Chattanooga, Tenn	--------	--------	[1] 1.27	1.31	1.33	1.34
Chicago, Ill	--------	--------	1.09	1.20	[2] 1.16	([3])
Cincinnati, Ohio	--------	--------	[2] 1.15	1.20	1.24	1.24
Cleveland, Ohio	--------	--------	1.09	1.23	1.21	1.24
Dallas, Texas	--------	[1] 1.35	1.19	1.20	1.20	1.28
Denver, Colo	[1] 1.10	1.18	1.02	1.08	1.03	1.03
Des Moines, Iowa	--------	[1] 1.10	1.00	[2] 1.08	1.07	1.10
Detroit, Mich	--------	--------	1.13	1.20	1.19	1.20
Grand Rapids, Mich	--------	--------	[2] 1.20	1.28	1.24	1.26
Hartford, Conn	--------	1.21	1.10	1.26	1.19	1.21
Helena, Mont	--------	[1] 1.00	1.10	1.09	1.04	1.07
Honolulu, Hawaii	--------	1.07	1.04	1.09	1.05	0.97
Idaho Falls, Idaho	[1] 1.10	1.03	1.05	1.11	1.05	1.00
Indianapolis, Ind	--------	--------	1.06	1.25	1.26	1.28
Jackson, Miss	--------	--------	[2] 1.25	1.35	1.37	1.34
Kansas City, Mo	--------	1.10	1.05	1.05	1.05	0.99
Laramie, Wyo	--------	1.10	1.01	1.07	1.06	1.02
Las Vegas, Nev	[1] 1.10	[2] 1.15	0.99	1.02	1.03	0.97
Little Rock, Ark	--------	--------	[2] 1.20	[2] 1.21	1.27	1.22
Louisville, Ky	--------	1.24	1.11	1.23	1.21	1.22
Manchester, N.H	--------	1.31	1.13	1.23	1.21	1.26
Memphis, Tenn	--------	--------	[1] 1.22	1.27	1.30	1.26
Milwaukee, Wis	--------	--------	1.11	1.19	1.23	1.28
Minneapolis, Minn	--------	--------	1.00	1.08	1.00	1.01
New Orleans, La	--------	--------	1.23	1.28	1.31	1.34
New York, N.Y	--------	[1] 1.24	1.06	1.19	[2] 1.18	1.22
Norfolk, Va	--------	--------	1.16	1.24	[2] 1.20	([3])
Oklahoma City, Okla	--------	--------	1.15	1.20	1.29	1.32
Omaha, Nebr	--------	--------	[2] 1.00	1.06	1.05	0.98
Palmer, Alaska	[1] 1.10	1.10	1.09	1.07	1.08	1.00
Philadelphia, Pa	--------	[1] 1.25	1.10	1.22	1.27	1.29
Phoenix, Ariz	--------	--------	1.00	1.04	1.09	1.01
Pittsburgh, Pa	--------	1.24	[2] 1.17	1.22	1.24	1.26
Portland, Me	--------	[1] 1.22	1.09	1.16	[2] 1.20	([3])
Portland, Oreg	--------	1.10	1.09	1.18	1.11	1.06
Providence, R.I	--------	[1] 1.29	1.10	1.29	1.28	1.30
Sacramento, Calif	--------	--------	[2] 1.05	1.07	1.12	1.06
Salt Lake City, Utah	[1] 1.20	1.10	1.08	1.07	1.05	1.04
San Francisco, Calif	--------	[1] 1.10	1.07	1.16	1.05	0.99
San Juan, P.R	--------	--------	1.12	1.19	1.15	1.23
Seattle, Wash	--------	1.10	1.07	1.10	1.09	1.08
Spokane, Wash	--------	1.05	1.05	1.15	1.12	1.18
St. Louis, Mo	--------	--------	[2] 1.02	1.07	1.01	0.98
Syracuse, N.Y	--------	1.28	1.16	1.23	1.22	1.25
Tampa, Fla	--------	--------	[2] 1.24	1.27	1.26	1.22
Trenton, N.J	--------	[1] 1.26	1.12	1.31	1.24	1.28
Washington, D.C	--------	--------	1.13	1.21	1.23	1.30
Wichita, Kans	--------	1.13	1.03	1.09	1.05	1.00
Wilmington, Del	--------	[1] 1.26	1.18	1.22	1.22	1.26
Network average	--------	1.15	1.11	1.19	1.18	1.17

[1] Average based on one month.
[2] Average based on two months.
[3] Sample lost.

Strontium-90 In Canadian Dried Milk Products

The following table presents the results of strontium-90 determinations in Canadian dried milk samples for the months of October, November, and December, 1960. This table was included in the "Quarterly Report of the Radio-Active Fallout Study Program," dated April 1961, published by the Radiation Protection Division of the Department of National Health and Welfare, Ottawa, Canada. Figure 1 illustrates the sampling locations.

Data for the previous months in 1960 were published in *Radiological Health Data,* Volume I, Numbers 6 and 9, and Volume II, No. 4.

FIGURE 1.—MILK SAMPLING STATIONS IN CANADA

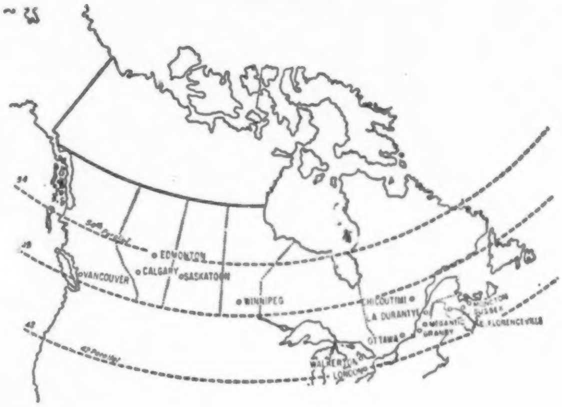

TABLE 1.—STRONTIUM-90 CONTENT OF CANADIAN DRIED MILK POWDER SAMPLES, FOURTH QUARTER 1960

[Concentrations in $\mu\mu c$/gm calcium]

Station	October	November	December
Calgary	13.2	8.0	15.6
Charlottetown	[3] NS	NS	NS
Chicoutimi	10.4	13.8	12.4
E. Florenceville	11.4	11.7	NS
Edmonton [1]	8.7	7.3	10.5
Granby [1]	12.4	21.2	8.6
La Durantye	14.0	13.0	14.0
London [1]	3.6	4.2	4.7
Megantic	8.3	12.6	8.1
Moncton [1,2]	11.4	11.6	9.6
Ottawa [1]	4.7	6.9	4.9
Saskatoon [2]	5.5	7.1	9.6
Sussex	9.3	10.7	10.1
Vancouver [1]	10.4	10.5	12.7
Walkerton	3.9	5.6	4.7
Winnipeg [2]	6.3	6.6	7.2
Average	8.9	10.0	9.5

[1] Natural strontium determinations made for these stations. All other stations were corrected for natural strontium using an average factor of 1.06.
[2] Buttermilk sample. All other samples are skim milk.
[3] NS = No milk powder manufactured for the month.
Samples collected by inspectors of the Marketing Division, Department of Agriculture.

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SECTION IV. — WATER

National Water Quality Network

Division of Water Supply and Pollution Control
Public Health Service

The National Water Quality Network was established under the provision of Section 4(c) of Public Law 660, which states ". . . The Surgeon General shall . . . collect and disseminate basic data . . . (relating) to water pollution and the prevention and control thereof."

This Network, operated in cooperation with State and local health agencies, was started in October 1957. At present, there are 86 sampling stations located on major waterways used for public water supply, propagation of fish and wildlife, recreational purposes, and for agricultural, industrial, and other uses. Some of these stations are on interstate, coastal, and International Boundary waters, and waters on which activities of the Federal Government may have an impact. Ultimately, a total of 250 to 300 stations will be in operation. A few of the more recently established stations have not begun to report radioactivity.

Samples of water are examined for chemical, physical, and biological quality insofar as these relate to pollution. Samples for some determinations are taken weekly, others monthly, and for some, continuous composite samples of 10 to 15 days are obtained.

Gross alpha and beta measurements are made on both suspended and dissolved solids in the raw surface water samples. The levels of radioactivity associated with dissolved solids provide a rough measure of levels which may be found in a treated water, where such water treatment removes substantially all of the suspended matter. Naturally-occurring radioactive substances in the environment are the source of essentially all of the alpha activity. The contamination of the environment from man-made sources is the major contributor to the beta activity. It should be noted that with the cessation of weapons testing, beta activity in most raw waters is generally approaching a level attributable solely to natural beta activity. Natural beta activity can be two or three times the natural alpha activity based on the presence of the same nuclides. Some exceptions to this are seen, notably the data for the Columbia River and the Animas River.

While beta determinations for the first two years of the Network operation have been conducted on each sample weekly, the alpha determinations are reported generally on a composite sample of more than one week. Beginning with samples taken in January 1960, beta determinations were performed on composite samples obtained by combining two weekly samples. The alpha data will be reported on three-month composite samples, with ¼ of the stations being covered each month.

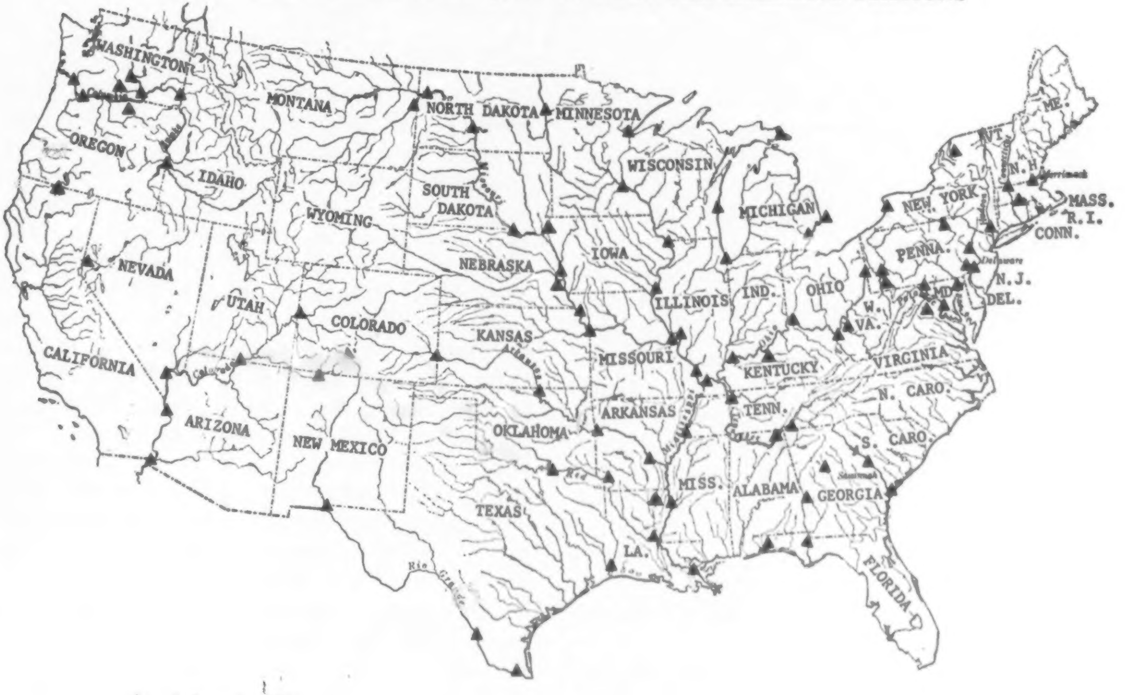
All the data reported in table 1 represent the average of all information available for the month indicated.

Strontium-90 data reported are the results of determinations on composite samples for a three-month period ending in the month shown.

Additional information and data may be obtained from the following sources:

1. "National Water Quality Network Annual Compilation of Data," PHS Publication. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Price $1.50.
2. "Report on National Water Quality Control Network," submitted by Dr. F. J. Weber, Chief, Division of Radiological Health, PHS, at the Joint Committee on Atomic Energy Hearings on Fallout from Nuclear Weapons Tests, Vol. 1, May 1959, pages 167–169.
3. Setter, L. R., Regnier, J. E., and Diephaus, A. "Radioactivity of Surface waters in the United States," Jour. AWWA *51,* 1377 (1959).
4. Straub, C. P., Setter, L. R., Goldin S., and Hallbach, P. F., "Strontium-90 in Surface Waters," Jour. AWWA *52,* 756 (1960).
5. Setter, L. R., and Baker, S. L., "Radioactivity of Surface Waters in the United States," *Radiological Health Data,* Volume I, No. 7 (1960).

FIGURE 1.—NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS



As of June 1, 1961

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS

[Concentrations in $\mu\mu c$/liter]

Station	Quarter ending December 31, 1960	February 1961					
		Beta activity			Alpha activity		
	Strontium-90	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River: Pittsburgh, Pa.	—	0	0	0	0	0	0
Animas River: Cedar Hill, N. Mex.	—	24	20	44	10	18	28
Apalachicola River: Chattahoochie, Fla.	—	0	0	0	—	—	—
Arkansas River: Ponca City, Okla.	—	0	0	0	8	4	12
Chattahoochie River:							
Atlanta, Ga.	0.3	2	5	7	0	0	0
Columbus, Ga.	—	3	0	3	0	0	0
Colorado River:							
Loma, Colo.	—	0	0	0	4	5	9
Page, Ariz.	0.4	271	24	295	54	10	64
Hoover Dam, Ariz.-Nev.	—	0	4	4	0	5	5
Parker Dam, Ariz.-Calif.	1.2	0	6	6	0	6	6
Yuma, Ariz.	—	0	0	0	<1	4	5
Columbia River:							
Wenatchee, Wash.	—	0	0	0	0	0	0
Pasco, Wash.	—	105	593	698	0	0	0
Bonneville Dam, Oreg.	0.5	86	139	225	—	—	—
Clatskanie, Oreg.	—	23	48	71	0	0	0
Delaware River: Martin's Creek, Pa.	—	0	0	0	0	0	0
Escambia River:							
Century, Fla.	(1)	0	0	0	0	0	0
Great Lakes:							
Gary, Ind.	—	0	1	1	0	0	0
Duluth, Minn.	—	0	0	0	0	0	0
Milwaukee, Wis.	0.2	0	0	0	0	0	0
Hudson River: Poughkeepsie, N.Y.	0.4	0	0	0	1	0	1
Illinois River: Peoria, Ill.	0.5	0	0	0	0	1	1
Kanawha River: Winfield Dam, W.Va.	—	2	0	2	3	0	3
Klamath River: Copco, Oreg.	—	0	0	0	<1	0	<1
Little Miami River: Cincinnati, O.	(1)	1	<1	1	1	<1	1
Mississippi River:							
West Memphis, Ark.	1.0	0	5	5	2	1	3
Delta, La.	—	0	7	7	2	0	2
New Orleans, La.	—	2	6	8	3	1	4
Missouri River:							
Williston, N.D.	—	0	2	2	1	5	6
Bismarck, N.D.	—	2	1	3	0	2	2
St. Joseph, Mo.	0.5	0	2	2	6	4	10
St. Louis, Mo.	—	0	2	2	21	2	23
Ohio River:							
East Liverpool, O.	—	0	0	0	0	0	0
Wheeling, W. Va.	0.6	—	—	—	—	—	—
Cincinnati, Ohio	—	2	0	2	2	0	2
Cairo, Ill.	—	4	0	4	1	0	1
Red River, North: Grand Forks, N.D.	—	<1	5	5	0	0	0
Red River, South: Denison, Tex.	0.7	0	0	0	1	1	2
Rio Grande River:							
Alamosa, Colo.	—	0	2	2	0	<1	<1
El Paso, Tex.	—	0	0	0	<1	<1	1
Laredo, Tex.	—	0	0	0	1	1	2
Brownsville, Tex.	—	0	0	0	—	—	—
Sabine River: Ruliff, Tex.	—	4	0	4	2	0	2
St. Clair River: Port Huron, Mich.	—	0	0	0	0	0	0
St. Lawrence River: Massena, N.Y.	0.6	4	4	8	0	<1	<1
Schuylkill River: Philadelphia, Pa.	(1)	0	0	0	3	0	3
Savannah River:							
Port Wentworth, Ga.	0.5	2	10	12	1	0	1
North Augusta, S.C.	—	0	0	0	0	0	0
Snake River: Wawawai, Wash.	—	0	0	0	0	1	1
Susquehanna River:							
Sayre, Pa.	—	0	0	0	0	0	0
Conowingo, Md.	0.4	0	<1	<1	<1	<1	1
Tennessee River:							
Chattanooga, Tenn.	0.9	9	55	64	—	—	—
Bridgeport, Ala.	—	4	111	115	0	<1	<1
Yellowstone River: Sidney, Mont.	—	1	0	1	0	5	5

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[1] Insufficient sample for analysis.

Analyses of Cistern Water

Division of Radiological Health, Public Health Service, and U.S. Coast Guard

Monthly samples of several U.S. Coast Guard roof-collected rain water cistern supplies are routinely analyzed for beta activity by the Robert A. Taft Sanitary Engineering Center, Public Health Service, Cincinnati, Ohio. Some samples are composited each three months and further analyzed for strontium-90 activity. Additional data concerning this investigation appears in the "Statement on New Data on Uptake in Milk, Food and Human Bone," by C. P. Straub, submitted to the Joint Committee Hearings on Fallout from Nuclear Weapons, May 1959, Volume II, page 990.

A few of the results presented in table 1 have appeared previously in *Radiological Health Data*, Volume I, Number 3.

TABLE 1.—U.S. COAST GUARD CISTERN WATER SAMPLES, FOURTH QUARTER 1959

Location	Date collected	Solids (ppm)		Beta activity (μμc/liter)	
		Suspended	Dissolved	Dissolved	Total
Cape Flattery, Wash.	November 6	20	46	18	46
Cape Hatteras, N.C.	October 28	8	36	14	28
	November 30	14	44	25	27
	December 18	20	22	6	7
Catanduanes, Panay Island, P.I.	October 15	12	78	4	4
Cobb Island, Md.	October 30	2	53	36	47
	November 30	17	47	20	29
Cocos Island, Marianas, Guam	October 19	15	101	20	24
Cuckolds, Maine	October 28	21	71	15	15
	December 5	13	260	0	22
	December 28	10	161	12	12
French Frigate, Shoals, Hawaii	October 15	21	456	51	72
Grand Island, La.	November 4	16	60	4	4
	December 16[1]	38	170	9	9
Iwo Jima	October 26	13	51	7	7
Kwajalein, Marshall Island	October 15	9	48	10	19
Metomkin Bay, Va.	October 26	14	32	25	33
	December 1	20	81	60	63
	December 21	7	65	34	41
Moose Peak, Maine	October 31	18	322	38	43
	December 2	16	165	15	16
	December 29	12	191	11	11
Patos Island, Wash.	November 1	29	73	8	9
	December 10	10	65	4	4
Port O'Conner, Tex.	November 20	16	72	16	25
	December 21	17	78	17	22
Swansboro, N.C.	October 27	14	96	30	47
	December 3	10	74	33	37
	December 28	11	64	43	60
Wake Island	October 8	16	224	24	27

[1] 3,200 gallons purchased water added.

TABLE 2.—U.S. COAST GUARD CISTERN WATER SAMPLES, FIRST QUARTER, 1960

Location	Date collected	Solids (ppm)		Beta activity (μμc/liter)	
		Suspended	Dissolved	Dissolved	Total
Cape Flattery, Wash.	January 1	10	72	18	21
	February 1	8	89	15	15
	March 4	16	132	26	26
Cape Hatteras, N.C.	January 20	28	30	9	9
	February 29	11	42	25	37
	March 21	18	33	32	40
Cobb Island, Md.	February 2	13	70	31	40
Cuckolds, Maine	January 22[1]	26	75	5	5
	February 25	19	268	4	4
Grand Island, La.	January 6	15	140	7	7
	February 1[2]	19	136	4	5
	March 21	16	66	9	11
Metomkin Bay, Va.	January 20	29	122	36	45
	March 18	2	139	50	60
Moose Peak, Maine	January 27	13	143	[3] ND	12
Patos Island, Wash.	January 28	20	65	[3] ND	[3] ND
	February 29	8	61	[3] ND	[3] ND
Port O'Conner, Tex.	January 20	20	172	16	22
Swansboro, N.C.	January	23	109	23	23
	February 23	5	263	6	23

[1] 2,200 gallons from Portland, Maine added.
[2] 6,400 gallons purchased water added.
[3] ND = Non-detectable.

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TABLE 3.--U.S. COAST GUARD CISTERN WATER SAMPLES, STRONTIUM-90 AND GROSS BETA DETERMINATIONS, SECOND QUARTER, 1960

[Concentrations in μμc/liter]

Location	Gross beta activity			Sr^{90}
	Dissolved[1]	Total[1]	Total[2]	
Atlantic Coastal States				
Cape Hatteras, N.C.	11.9	17.8	28.1	1.6
Cobb Island, Md.	30.4	45.1	70.8	3.5
Cuckolds, Maine[3]	....	....	12.0	1.2
Metomkin Bay, Va.	35.0	49.2	78.6	4.6
Moose Peak, Maine	14.2	18.0	28.8	1.9
Swansboro, N.C.	26.5	33.1	52.4	2.3
Average, excluding Cuckolds, Maine	....	....	51.7	2.8
Gulf States				
Grand Island, La.[3]	13.4	14.7	23.4	1.3
Houston, Tex., Rain	....	....	....	11.5
Port O'Conner, Tex.	13.6	17.3	26.6	3.0
Mid-West				
Montgomery, Ohio	14.9	22.5	33.8	2.5
Pacific Coastal States				
Cape Flattery, Wash.	22.1	49.2	75.6	2.1
Patos Island,[3] Wash.	0.05	0.05	....	0.6
U.S. Average, excluding Cuckolds, Grand Island and Patos Island	....	....	49.3	2.7

[1] Average of observed values obtained usually within ten days after collection.

[2] Average of observed values extrapolated to one-year-old mixed products assuming detonation on November 3, 1958.

[3] Records show that substantial volumes of non-rain potable drinking water was added to the cistern.

SECTION V. — OTHER DATA

External Gamma Activity

Radiation Surveillance Network, Public Health Service

Portable survey instruments are available at stations of the Radiation Surveillance Network for recording levels of external gamma radiation. Measurements are made daily approximately three feet above the ground. These readings are not precise but are sufficiently accurate to illustrate any significant variations above background. The differences among the values shown in the following table are within the variance anticipated due to differences in normal background and instrument response characteristics.

TABLE 1.—EXTERNAL GAMMA ACTIVITY, MARCH 1961

Station location	Average (mr/hr)	Station location	Average (mr/hr)	Station location	Average (mr/hr)
Anchorage, Alaska	0.01	Indianapolis, Ind	0.01	Oklahoma City, Okla	0.01
Fairbanks, Alaska	(1)	Iowa City, Iowa	0.01	Ponca City, Okla	0.04
Juneau, Alaska	0.01	Topeka, Kan	0.02	Portland, Oreg	0.02
Phoenix, Ariz	0.01	New Orleans, La	0.01	Harrisburg, Pa	0.01
Little Rock, Ark	0.01	Baltimore, Md	0.02	Providence, R.I	0.02
Berkeley, Calif	0.01	Lawrence, Mass	0.02	Columbia, S.C	0.02
Los Angeles, Calif	0.01	Lansing, Mich	0.02	Cincinnati, Ohio	(1)
Denver, Colo	0.02	Minneapolis, Minn	0.01	Pierre, S.Dak	0.02
Hartford, Conn	0.02	Pascagoula, Miss	(1)	Austin, Tex	0.01
District of Columbia	0.02	Jefferson City, Mo	0.01	El Paso, Tex	0.02
Jacksonville, Fla	0.02	Helena, Mont	0.03	Salt Lake City, Utah	0.02
Atlanta, Ga	(1)	Trenton, N.J	0.02	Richmond, Va	0.01
Honolulu, Hawaii	0.03	Santa Fe, N.M	0.04	Seattle, Wash	0.02
Boise, Idaho	0.01	Albany, N.Y	0.02	Madison, Wis	0.01
Springfield, Ill	0.01	Gastonia, N.C	0.02	Cheyenne, Wyo	0.02

[1] No Data Received.

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ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission is providing data on environmental levels of radioactivity in the vicinity of major Commission installations to the Public Health Service on a quarterly basis. The data are from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Radiological Health Data, Volume I, Numbers 8 and 9, and Volume II, Numbers 1 through 7 contain summaries for 17 installations. Summaries follow for the Connecticut Aircraft Nuclear Engine Laboratory, Mound Laboratory, Portsmouth Gaseous Diffusion Plant, and the Savannah River Plant for the fourth quarter of 1960.

Connecticut Aircraft Nuclear Engine Laboratory

Pratt and Whitney Aircraft,
Division of United Aircraft Corporation
Middletown, Connecticut

—Issued December 1960 and April 1961

Environmental levels of radioactivity at the Connecticut Aircraft Nuclear Engine Laboratory (CANEL) for 1959 and the first and second quarters of 1960 were reported in *Radiological Health Data,* Volume I, No. 8 and Volume II, No. 2. The following report presents a summary of the data for the third quarter and an annual summary for 1960. Due to a change in defense planning the Government has canceled the development of a nuclear aircraft engine. Therefore, it is contemplated that subsequent reports by CANEL will not be issued.

The environmental monitoring program at CANEL consists of collecting and analyzing samples of drinking water, Connecticut River water, process water, domestic sewer water, precipitation, and air.

The CANEL facility has three retention tank vaults which are designed to collect laboratory wastes which might be radioactive. These tanks are sampled and analyzed before their contents are discharged to the Connecticut River. All samples are analyzed for gross alpha and beta activity.

Air Monitoring

One-hundred and eighty air samples were collected at a central location (weather station) during 1960. All samples were collected with a high volume air sampler, and each sample was allowed to decay at least 7 days before any gross alpha and beta analyses were made. Twenty-eight air samples were collected from random locations either on or in the vicinity of CANEL during this period. Table 1 presents the data for the air monitoring at the weather station and other randomly selected sites.

TABLE 1.—ATMOSPHERIC GROSS ALPHA AND BETA CONCENTRATIONS, 1960

[Average concentrations in $\mu\mu c/m^3$]

Location	Third quarter			Annual summary		
	Number of samples	Alpha	Beta	Number of samples	Alpha	Beta
Weather station	52	0.001	0.237	180	0.002	0.170
On and around CANEL site	10	0.001	0.132	28	0.002	0.224

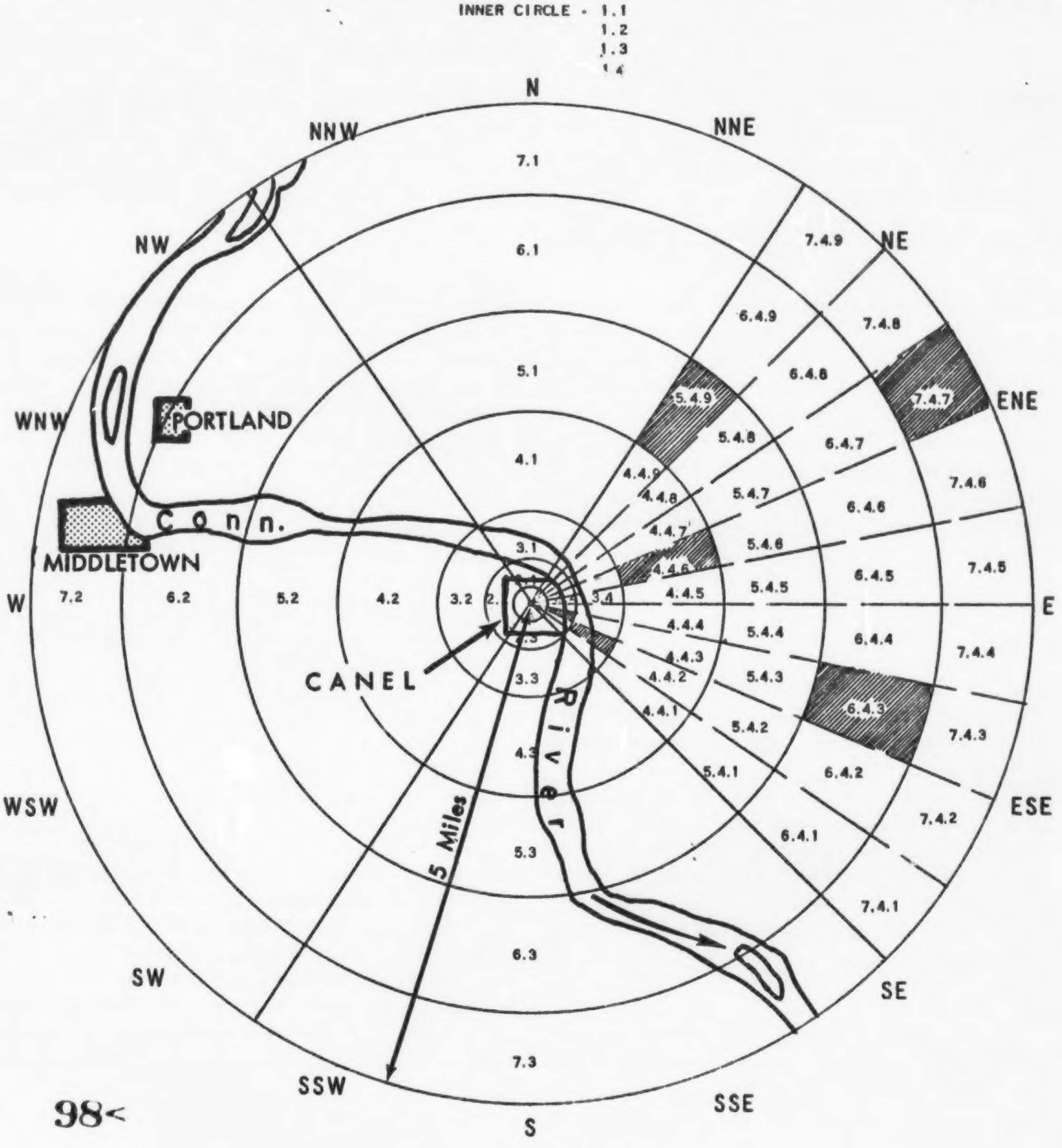
The average alpha concentration shown above for the calendar year 1960 is equal to 5 percent of the MPC for unidentified alpha emitters for populations in the vicinity of a controlled area. Similarly, the average beta concentration is equal to 2 percent of its MPC. It should be noted that, on the average, both the alpha and beta concentrations are highly variable and the averages are not statistically significant.

These air samples were compared with air samples collected at random locations around the CANEL area in the preoperation period of 1957 and 1958. At a 95 percent significance level there was no significant difference in alpha concentration, but there was a significant decrease in beta concentration. There was also a significant decrease in beta concentration when 1960 samples were compared with 1959 samples. As in the case of fallout samples, it is possible that a significant decrease in activity may be noted for some time due to the time it takes for fission products to be eliminated from the atmosphere, assuming no new fission products are added to the atmosphere.

Water Monitoring

Environmental water samples were collected at 20 locations on and in the vicinity of the

FIGURE 1.—SAMPLING LOCATIONS, CONNECTICUT AIRCRAFT NUCLEAR ENGINE LABORATORY



CANEL site. Water samples were collected in each sector of an annulus, numbers 3.1 through 7.4 as shown in figure 1. The center of this diagram is near the center of the CANEL site, and the outer circle is at a distance of 5 miles from the center. Gross alpha and beta analyses are made on the soluble and insoluble portions of monthly samples from each location. The results from the third quarter and the yearly summary are presented in table 2.

TABLE 2.—GROSS RADIOACTIVITY IN ENVIRONMENTAL WATER, 1960

[Average concentrations in μμc/liter]

Activity	Third quarter			Annual summary		
	Number of samples	Soluble	Insoluble	Number of samples	Soluble	Insoluble
Alpha	60	0.17	0.15	240	0.25	0.44
Beta	60	7.61	5.88	240	5.28	4.27

All water samples were statistically analyzed using three variables of classification, i.e., date, distance, and direction. Significant effects have appeared for these variables and/or their combinations. These significant effects initiated a review of CANEL operations and a study of meteorological conditions. No unusual incidents occurred which could reasonably be expected to cause these variations. Selected stacks, which have the highest probability of emitting radioactive materials, have been continuously monitored. There is no evidence to justify concern about the amount of material which may have been released from these stacks. Therefore, it has been concluded that the statistically significant effects noted above were caused by natural variations and were not caused by CANEL operations. Also, even though statistically significant effects have appeared, the average level of total gross activity is only 10 percent of the MPC for populations in the vicinity of a controlled radiation area.

The 1960 water samples were compared with water samples taken in the preoperational period (1957 and 1958) by means of the "t-test." There was a significant decrease in activity at the 95 percent significance level. There was also a significant decrease when samples collected in 1960 were compared with samples collected in 1959.

There is no apparent cause for this decrease that can be attributed to CANEL operations. Since the higher levels of activity in the base period and 1959 were not attributed to CANEL operations, it is concluded that the indicated decreases are due to a decrease in natural or man-made activity external to CANEL.

Samples of drinking water were collected from two wells in use on the CANEL site. Samples were collected once every 20 days. The well sampled on a given date was the one in use at that time. The data are shown in table 3.

TABLE 3.—GROSS ALPHA AND BETA CONCENTRATIONS IN WELL WATER, 1960

[Average concentrations in μμc/liter]

Activity	Third quarter			Annual summary		
	Number of samples	Soluble	Insoluble	Number of samples	Soluble	Insoluble
Alpha	4	0.28	0.14	16	0.38	0.20
Beta	4	3.36	7.67	16	3.20	6.40

The average total gross concentration of radioactivity in drinking water from the two wells for the calendar year was 10.2 μμc/liter. This is equivalent to 10.2 percent of the MPC for populations in the vicinity of a controlled area. The results for 1960 were significantly greater than the activity in the preoperational period. However, there was no significant difference at the 95 percent significance level when comparing 1960 results with 1959 results.

Samples of Connecticut River water were collected monthly at two locations throughout the year. One location is near the north boundary of the CANEL site (upstream of CANEL effluent), and the other is near the south boundary (downstream of CANEL effluent). A total of 26 samples was taken throughout the year. Table 4 presents the

TABLE 4.—GROSS ALPHA AND BETA CONCENTRATIONS IN CONNECTICUT RIVER WATER, 1960

[Average concentrations in μμc/liter]

Location	Activity	Third quarter		Annual summary	
		Soluble	Insoluble	Soluble	Insoluble
North boundary of site.	Alpha	0.18	0.95	0.15	0.49
	Beta	22.66	16.17	8.34	8.80
South boundary of site.	Alpha	0.14	0.79	0.24	0.42
	Beta	2.96	13.18	4.75	7.61

gross alpha and beta analyses on the soluble and insoluble portions of these samples.

The north samples were compared with south samples by means of the "t-test," and it was found that there was no statistically significant difference between the two locations.

The average total gross activity for the 26 samples taken during the years was 15.4 μμc/liter. This is equivalent to 15 percent of the MPC for off-site drinking water.

Precipitation

A total of 87 precipitation samples was collected at the weather station during 1960. The gross alpha and beta analyses made on the soluble and insoluble portions of the samples are presented in table 5.

The average total gross activity in precipitation was 46.4 μμc/liter for calendar year 1960. This would be equivalent to 46 percent of the MPC if this water were used as drinking water off-site. When compared to prior years these data show a significant decrease in activity. This decrease in activity in precipitation samples could conceivably go on for a few years. It may take several years for the activity in the atmosphere to be eliminated to such a concentration that significant decreases from year to year will not be detected.

TABLE 5.—GROSS ALPHA AND BETA IN PRECIPITATION, 1960

[Average concentrations in μμc/liter]

Activity	Third quarter		Annual summary	
	Soluble	Insoluble	Soluble	Insoluble
Alpha	0.40	0.11	0.91	0.35
Beta	27.30	8.03	34.80	10.33

Mound Laboratory

Monsanto Chemical Company
Miamisburg, Ohio

—Issued March 1961

Environmental levels of radioactivity at Mound Laboratory for 1959 and the first three quarters of 1960 were reported in *Radiological Health Data*, Volume I, Number 8, and Volume II, Number 3. The following report presents the data for the fourth quarter of 1960.

During the fourth quarter, no radioactive materials were used which might have contributed any measurable penetrating radiation such as gamma or hard beta to the environment. Polonium, plutonium and tritium are the possible air contaminants; polonium and tritium are possible river water contaminants.

Air Monitoring

Monitoring of the environmental air for tritium concentrations, by means of a continuous air monitor mounted in a panel truck, was performed routinely out to a distance of 20 miles from the laboratory. A total of 96 evaluations were made of 70 locations. The sampling locations for tritium are the same as the ones for polonium and plutonium. Figures 1 and 2 show the locations of sampling sites relative to Mound Laboratory. To date, the tritium concentrations in the environment have been immeasurable.

Monitoring for possible polonium and plutonium in the environment is accomplished by particulate air sampling equipment also mounted in the truck used for tritium air sampling. During this quarter, a total of 154 air samples were collected and analyzed. The long-lived gross alpha determination on collected filter paper samples was made only after sufficient time had elapsed after collection to permit the decay of the short-lived daughter products, randon and thoron. Filter paper samples are counted for alpha particle emission in a low background proportional counter.

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Table 1 presents the gross alpha activity in air from polonium and plutonium.

FIGURE 1.—CLOSE-IN AIR SAMPLING LOCATIONS, MOUND LABORATORY

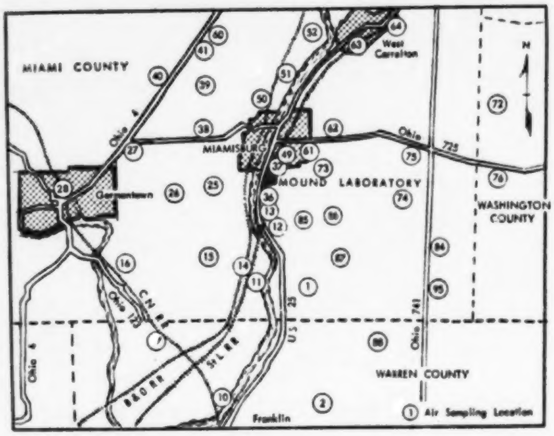


FIGURE 2.—DISTANT AIR SAMPLING LOCATIONS, MOUND LABORATORY

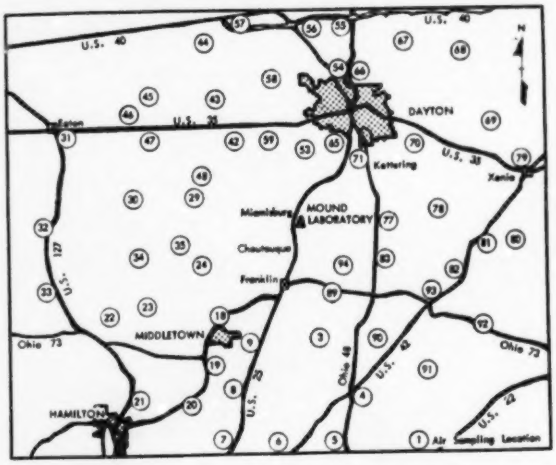


TABLE 1.—GROSS ALPHA ACTIVITY IN AIR FROM POLONIUM AND PLUTONIUM, FOURTH QUARTER 1960

Location number (see fig. 1 and 2)	Number of samples	Average concentration (μμc/m³)	Location number	Number of samples	Average concentration (μμc/m³)
1	1	0.031			
2	1	0.020	48	1	0.029
3	1	0.019	61	5	0.030
4	1	0.051	62	5	0.025
5	1	0.041	63	5	0.019
6	1	0.041	64	5	0.011
7	1	0.009	65	5	0.014
8	1	0.032	66	5	0.018
9	1	0.028	67	5	0.012
10	1	ND	68	5	0.007
11	1	0.002	69	5	0.006
12	1	0.022	70	5	0.008
13	3	0.037	71	5	0.006
14	3	0.013	72	5	0.011
15	3	0.014	73	1	0.019
16	3	0.011	74	1	0.010
17	3	0.004	75	1	0.016
18	3	0.001	76	1	0.023
19	3	0.010	77	1	0.065
20	3	ND	78	1	0.032
21	3	0.015	79	1	0.020
22	3	0.005	80	1	0.004
23	3	0.011	81	1	0.015
24	3	0.014	82	1	0.014
37	1	0.042	83	1	0.007
38	1	0.071	84	1	0.048
39	1	0.065	85	2	0.003
40	1	0.078	86	2	0.019
41	1	0.122	87	2	0.002
42	1	0.046	88	2	0.029
43	1	0.079	89	2	0.064
44	1	0.028	90	2	0.002
45	1	0.315	91	2	0.028
46	1	0.025	92	2	0.011
47	1	0.028	93	2	ND
			94	2	0.001
			95	2	0.004
			Average	154	0.020

Alpha concentrations detected in environmental air were very low. A long counting time analysis was performed for each filter sample in order to obtain good counting precision. At the low concentrations detected, the isotopes of polonium and plutonium are not distinguishable from each other or from the natural background radioactivity in the air. If the gross alpha detected in the environment (see table 1) is compared to the maximum permissible concentration for polonium, and one assumes that all alpha activity detected is polonium, the average polonium concentration would be <0.1% MPC. The polonium effluent stack monitoring program for this quarter has shown that essentially no detectable polonium would be expected in the environment due to the operations at Mound Laboratory.

If the gross alpha detected in the environment is compared to the MPC for continuous exposure of populations in the vicinity of a controlled area, and it is assumed that all alpha activity detected is plutonium, the average plutonium concentration would be well within the MPC; however, it would be a significant 33 percent of the MPC. In order to determine the impact of Mound Laboratory plutonium work on the environment, it must be pointed out that the natural background concentration of alpha contamination in the air in Southwestern Ohio is in the range of, and frequently exceeds the very low MPC for plutonium. That is to say the normal long-lived gross alpha count in the environment is usually a very significant percent of, and frequently exceeds the permitted alpha count for plutonium if the total count were attributed to plutonium. The impact of plutonium work at Mound Laboratory is also placed in proper focus by referring to plutonium stack monitoring data. During the fourth quarter of 1960, the average concentration of plutonium in air discharged from the stack was well within the permissible concentration for environmental air. For this reason, and the fact that the air is discharged to the environment from a 200 foot stack at a high velocity, we can say that the plutonium operations, as well as the polonium work, has contributed an insignificant amount of radioactivity to that normally present in the atmosphere.

Water Monitoring

Liquid radioactive waste materials from polonium work at the laboratory are processed in a special waste disposal plant designed to reduce radioactivity to a concentration level at which it may be discharged to the Great Miami River. Liquid waste from the plutonium work is small in volume. It is handled separately as a packaged waste and is not discharged to the river. Helium-3 being purified at Mound Laboratory yields small quantities of tritium. Liquid wastes from this work, also small in volume are treated separately (diluted with water when necessary) to assure that the radioactive content is within the maximum permissible concentration for discharge to the Great Miami River.

Samples are collected routinely each week from the laboratory effluent stream at the point of discharge and in the Great Miami River downstream to a distance of five miles. Once each quarter, river water samples are collected at various locations between Franklin, Ohio, and Elizabethtown, Ohio, where the Great Miami River enters the Ohio River. A weekly water sample is also collected from a drainage ditch which runs through the plant site. This ditch carries off all storm sewer water which eventually empties into the river. The treated liquid tritium waste is discharged into the storm sewers and the waste disposal plant effluent is discharged directly into the river via a closed sewer line. All of the samples collected from the river are analyzed to determine the polonium concentration. The drainage ditch sample and part of the river samples are analyzed for tritium concentration.

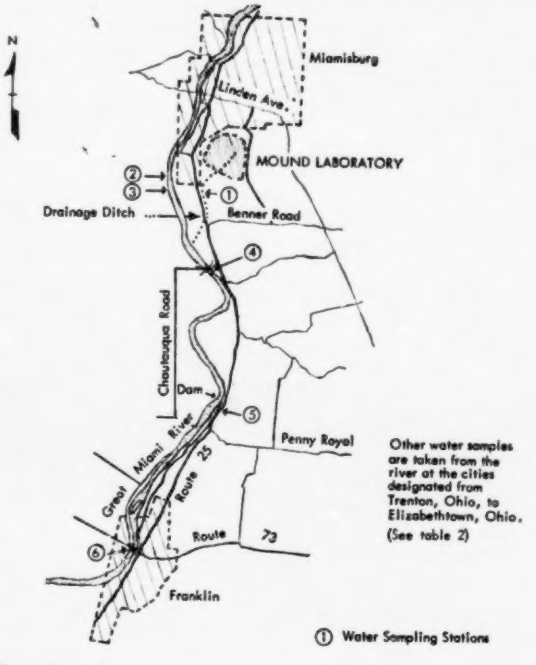
Data for the water monitoring in the Great Miami River are presented in table 2. Figure 3 shows the water sampling locations.

TABLE 2.—SUMMARY OF MONITORING FOR POLONIUM IN GREAT MIAMI RIVER, FOURTH QUARTER 1960

Sampling point number (see fig. 3)	Location	Number of samples	Average concentration ($\mu\mu c$/liter)
2	Mound Lab Effluent	11	15.60
3	250 yards downstream	11	0.98
4	Chautauqua Road Bridge	11	0.98
5	Chautauqua Dam	11	1.15
6	Franklin, Ohio	11	1.15
	Trenton, Ohio	1	ND[1]
	New Miami, Ohio	1	9.00
	7 miles north of New Baltimore, Ohio	1	1.80
	New Baltimore	1	ND
	Miamitown, Ohio	1	1.80
	5 miles north of Elizabethtown, Ohio	1	ND
	Elizabethtown, Ohio	1	ND

[1] ND = No detectable activity.

FIGURE 3.—WATER SAMPLING LOCATIONS IN GREAT MIAMI RIVER, MOUND LABORATORY



Other water samples are taken from the river at the cities designated from Trenton, Ohio, to Elizabethtown, Ohio. (See table 2)

Conclusion

Concentrations of radioactivity in the environment at Mound Laboratory are well within the maximum permissible concentrations recommended for populations in the vicinity of controlled areas by the National Committee on Radiation Protection and Measurements.

Portsmouth Gaseous Diffusion Plant

Goodyear Atomic Corporation
Portsmouth, Ohio

—Issued February 1961

Environmental levels of radioactivity at the Portsmouth Gaseous Diffusion Plant for 1959 and first, second, and third quarters of 1960 were reported in *Radiological Health Data*, Volume I, No. 8 and Volume II, No. 3. The following report presents a summary of the data for the fourth quarter of 1960.

The Atomic Energy Commission facility in Pike County, Ohio, is a gaseous diffusion plant operated by the Goodyear Atomic Corporation. The chemical processing of gaseous uranium presents the ordinary problems of the chemical industry which uses toxic solvents and extracting solutions. Fumes and mists must be controlled and contaminants removed by filtering, scrubbing, or other practical means to prevent atmospheric contamination.

An extensive environmental survey is conducted on a monthly basis for radioactive materials that may be released from the plant to check the effectiveness of controls which are used. The program is also designed to determine the effect, if any, on the surrounding environment. The routine program consists of sampling water, air, and the general radiation background levels. Sampling locations are shown in figure 1.

Included in this report for the first time are values for the limit of sensitivity for each type of instrument, the limit of sensitivity being the minimum detectable concentration of radiation.

The values for the maximum permissible concentrations (MPC) for uranium and thorium in air and water are 1/10th of the MPC allowed for continuous occupational exposure as given in National Bureau of Standards Handbook 69, issued June 5, 1959.

The results show that in no instance have the average values for any single location exceeded the maximum permissible concentrations or exposure levels for the population outside of the plant's boundaries. In general, the average levels for the fourth quarter of 1960, compared to the third quarter of 1960, are almost identical, except in the airborne beta-gamma, which is approximately one-half of the third quarter value.

FIGURE 1.—SAMPLING LOCATIONS, PORTSMOUTH GASEOUS DIFFUSION PLANT

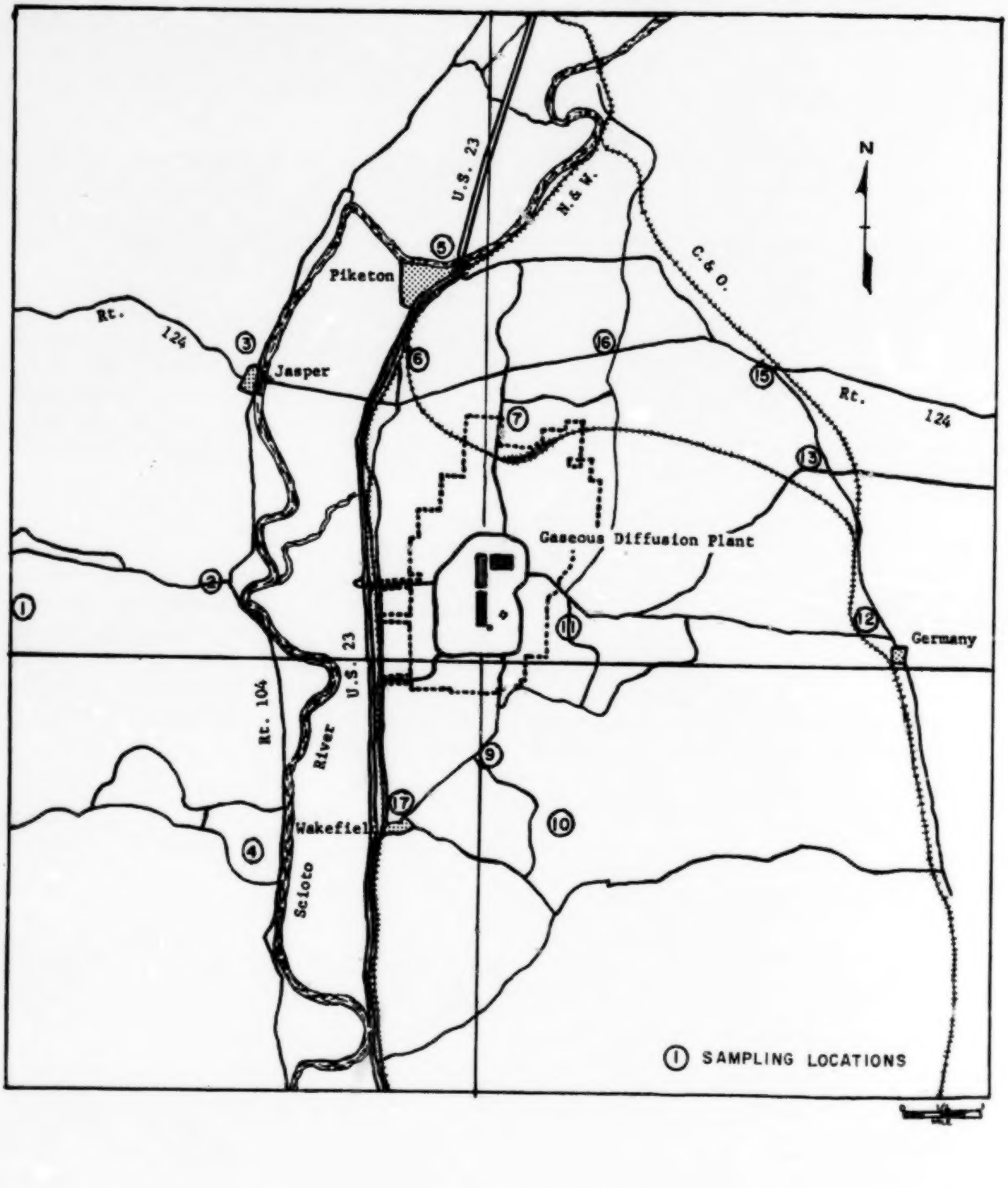


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TABLE 1.—GROSS ALPHA AND BETA-GAMMA CONCENTRATIONS IN AIR SAMPLES, FOURTH QUARTER 1960

[Average concentrations in $\mu\mu c/m^3$]

Location		Alpha [1]	Percent MPC	Beta-gamma [2]	Percent MPC
Number (See fig. 1)	From plant				
1	5-6 mi W	0.1	5	0.3	0.03
2	2-3 mi W	0.[illegible]	5	0.6	0.06
3	4 mi NW	0.1	5	0.1	0.04
4	3-4 mi SW	0.1	5	<0.007	0.00
5	4-5 mi N	0.1	5	0.2	0.02
6	2-3 mi NNW	0.1	5	0.4	0.04
7	2-3 mi N	0.1	5	0.1	0.01
9	1-2 mi S	0.1	5	0.2	0.02
10	3-4 mi SSE	0.1	5	0.4	0.04
11	1 mi E	0.1	5	0.5	0.05
12	5 mi E	0.1	5	0.2	0.02
13	5-6 mi NE	0.1	5	0.1	0.01
15	5-6 mi NE	0.1	5	0.2	0.02
16	4 mi NE	0.1	5	0.4	0.04
17	2-3 mi SSW	0.1	5	0.2	0.02
Average		0.1	5	0.3	0.03

[1] Minimum limit of sensitivity = 0.01 $\mu\mu c/m^3$.
[2] Minimum limit of sensitivity = 0.007 $\mu\mu c/m^3$.

TABLE 2.—GROSS ALPHA AND BETA-GAMMA CONCENTRATIONS IN STREAM WATER SAMPLES, FOURTH QUARTER 1960

[Average concentrations in $\mu\mu c$/liter]

Stream and location from plant	Alpha [1]	Percent MPC	Beta-gamma [2]	Percent MPC
Scioto River 4-5 mi SSW	1.5	0.01	14.0	0.07
Salt Creek 2-3 mi SSW	14.0	0.07	14.0	0.07
Salt Creek 1 mi S	7.0	0.04	19.0	0.10
Big Beaver 3-4 mi ENE	2.5	0.01	14.0	0.07
Big Beaver 2-3 mi NNW	5.0	0.03	19.0	0.10
Scioto River 4-5 mi N	8.0	0.04	14.0	0.07
Little Beaver 2 mi NW	82.0	0.41	178.0	0.89
Little Beaver 1-2 mi NNW	38.0	0.20	50.0	0.25
Plant drainage 0 mi SW	2.5	0.02	37.0	0.19
Plant drainage 0 mi W	8.0	0.04	14.0	0.07
Plant drainage 0 mi NE	150.5	0.75	119.0	0.59
Little Beaver 1 mi E	2.0	0.01	19.0	0.10
Big Beaver 2 mi NW	166.0	0.83	137.0	0.69
Scioto River 1-2 mi W	3.0	0.07	14.0	0.07
Average	35.0	0.18	47.0	0.24

[1] Minimum limit of sensitivity = 0.5 $\mu\mu c$/liter.
[2] Minimum limit of sensitivity = 14.0 $\mu\mu c$/liter.

TABLE 3.—GROSS BETA-GAMMA BACKGROUND RADIATION LEVELS, FOURTH QUARTER 1960

[Millirads/hour]

Location		Average rate [1]
Number (see fig. 1)	From plant	
1	5-6 mi W	0.013
2	2-3 mi W	0.015
3	4 mi NW	0.012
4	3-4 mi SW	0.014
5	4-5 mi N	0.014
6	2-3 mi NNW	0.011
7	2-3 mi N	0.013
9	1-2 mi S	0.014
10	3-4 mi SSE	0.015
11	1 mi E	0.012
12	5 mi E	0.016
13	5-6 mi NE	0.014
15	5-6 mi NE	0.015
16	4 mi NE	0.012
17	2-3 m SSW	0.015
	Average	0.014

[1] Limit of sensitivity = $1 \times 10,^{4}$ mr/hr.

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Savannah River Plant

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Aiken, South Carolina

—Issued March 1961

Environmental levels of radioactivity at the Savannah River Plant for 1959 and the first, second, and third quarters of 1960 were reported in *Radiological Health Data*, Volume I, No. 9 and Volume II, No. 5. The following report presents a summary of the data for the fourth quarter of 1960.

The Savannah River Plant maintains a continuous monitoring program to determine the concentration of radioactive materials in a 1200 square mile area outside the plant perimeter. Included are parts of Aiken, Barnwell, and Allendale Counties in South Carolina, and Richmond, Burke, and Screven Counties in Georgia. The regional monitoring data obtained from the continuous surveillance of the Savannah River Plant environs during the fourth quarter of 1960 are useful both as measures of the effectiveness of plant controls and as evidence of strict adherence to the maximum permissible concentrations (MPC) as recommended by the National Committee on Radiation Protection.

A basic principle guiding plant operations is the total containment of radioactive wastes. Although some very low level gaseous and liquid wastes are discharged to the environment in controlled releases, the dispersal is adequate to insure that the concentration is well below the MPC.

Instruments which can detect traces of radioactive materials several orders of magnitude below that of hazard significance are used to determine radioactivity in the environs. Frequently, radioactivity could not be detected in environmental samples; in such instances, the minimum concentration that could be accurately detected by the analysis were used in determining the average concentrations. These values (sensitivity of analysis) are presented in the tables. In most cases, possible plant contributed radioactivity was either so small that it was less than that which exists naturally or it was obscured by the residual fallout from global nuclear weapons testing programs. Since radioactive materials contributed by each of these sources cannot be readily separated or interpreted in terms of origin, all are included in the reported concentrations.

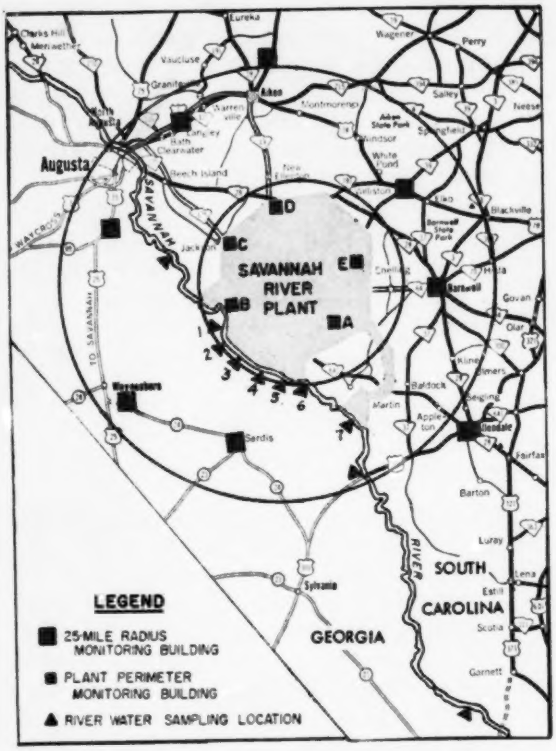
Atmospheric Monitoring

Air and rain water samples were collected continuously at 13 monitoring stations, including five locations at the plant perimeter and 8 locations which circumscribe an area extending approximately 25 miles from the center of a plant. These stations, forming two concentric circles around the plant, are spaced in such a manner that a significant plant release of radioactivity to the air would be detected regardless of prevailing wind conditions (see figure 1). Additional air monitoring stations were operated at Savannah and Macon, Georgia, and at Columbia and Greenville, South Carolina. These four facilities (see figure 2), at locations so distant that the effect of Savannah River Plant operations is minimum (approximately 100 miles from the plant), serve as "reference points" for determining background levels of activity. This system permits a comprehensive surveillance of the atmospheric radioactivity and, in addition, makes it possible to differentiate between weapons testing fallout and plant releases.

The atmospheric concentrations of radioactivity are given in table 1. Radioactivity in rainwater is presented in table 2.

The continued decreased concentrations of airborne weapons tests debris have provided the opportunity to investigate more closely the effect of stack releases on concentrations of filterable beta radioactivity in environmental air samples. No relationship was observed since plant releases were so low that the small differences among the values shown are within the variances due to differences in normal

FIGURE 1.—SAMPLING LOCATIONS, SAVANNAH RIVER PLANT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SAVANNAH RIVER PLANT
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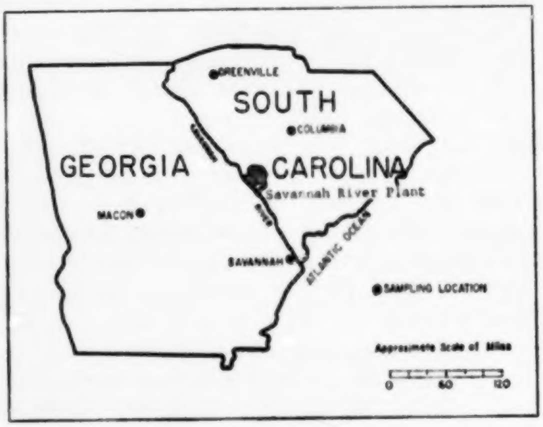
RIVER
SOUTH CAROLINA
GEORGIA
LEGEND
■ 25-MILE RADIUS MONITORING BUILDING
■ PLANT PERIMETER MONITORING BUILDING
▲ RIVER WATER SAMPLING LOCATION

FIGURE 2.—DISTANT AIR MONITORING STATIONS, SAVANNAH RIVER PLANT



background and statistical variation of analysis.

No radioiodine was detected in air or rainwater samples. For this reason, individual radioiodine data are not recorded. The minimum detection limits of radioiodine in air and rainwater (assuming use as drinking water) are 0.02 percent and 1.1 percent of the respective 1/10th MPCs.

TABLE 1.—GROSS ALPHA AND BETA CONCENTRATIONS IN AIR, FOURTH QUARTER 1960

[Average concentrations in $\mu\mu c/m^3$]

location	Alpha	Nonvolatile beta
Plant perimeter	0.0010	0.07
25 mile radius	0.0008	0.05
100 mile radius	0.0011	0.04
Percent of 1/10 MPC at plant perimeter	2.5	0.007
Sensitivity of analysis	0.0004	0.008

TABLE 2.—GROSS ALPHA AND BETA CONCENTRATIONS IN RAINWATER, FOURTH QUARTER 1960

[Average concentrations in $\mu\mu c$/liter]

Location	Alpha	Nonvolatile beta
Plant perimeter	0.4	22
25 mile radius	0.4	
100 mile radius	No sample	No sample
Percent of 1/10 MPC at plant perimeter	4.0	0.7
Sensitivity of analysis	0.2	4

Water Monitoring

Communities in the vicinity of the Savannah River Plant obtained drinking water from deep wells or small surface streams. Results of public water samples collected locally from 14 surrounding towns are essentially the same as those observed prior to the startup of the Savannah River Plant in 1951. The average concentrations measured during the quarter are presented in the following table. The close agreement with results obtained prior to startup show no effect due to the plant operations.

TABLE 3.—GROSS ALPHA AND BETA CONCENTRATIONS IN PUBLIC WATER SUPPLIES, FOURTH QUARTER 1960

[Average concentrations in $\mu\mu c$/liter]

Analysis	Concentration	Percent of 1/10 MPC	Sensitivity of analysis
Alpha	1.2	12	0.2
Nonvolatile beta	6.0	0.2	4.0

For measurement of radioactivity in the river, water is continuously collected at ten river locations upstream from, adjacent to, and as far as 60 miles downstream from the

TABLE 4.—GROSS RADIOACTIVITY CONCENTRATIONS IN SAVANNAH RIVER WATER, FOURTH QUARTER 1960

[Average concentrations in μμc/liter]

Location	Alpha	Nonvolatile beta	Tritium	Strontium-90 [1]
3 miles upstream of plant	0.2	4	10,000	0.30
At plant perimeter	0.2	17	----------	----------
10 miles downstream of plant	<0.2	31	15,000	0.09
60 miles downstream of plant	0.3	25	13,000	----------
Percent of 1/10 MPC at 10 miles downstream	2.0	1.0	0.4	0.7
Sensitivity of analysis	0.2	4	4,000	0.1

[1] These averages include samples collected during September, October, and November 1960.

plant. Results of samples collected during the quarter are shown in table 4. During the first weeks of this report period, water was collected at seven other river sampling locations by taking a single weekly sample, or "grab sample," which reflected conditions only at the time when the sample was taken. In November, continuous samplers were installed at all the river sampling locations. Quarterly average concentrations of radioactivity in river water indicate that plant operations contribute small amounts of radioactivity to the river, but that the resulting concentrations are far below the MPC value and are of no health significance.

Environmental Gamma Radiation Levels

Environmental gamma radiation dose rates, obtained from continuous measurements, are taken in each of 13 monitoring stations. Plant operations had no measurable effect on the radiation levels in the public zone. The average dose rates at the perimeter locations and at the 25 mile radius locations (both 0.015 mr/hr) are essentially the same as the external gamma radiation levels recorded at all North American stations of the PHS Radiation Surveillance Network in July 1960.

Vegetation and Food Monitoring

Radioactive contamination of vegetation may result from direct deposition on exposed surfaces of the plant or from absorption of the radioactivity from the soil by the root system. Bermuda grass was selected for analysis because of its importance as a pasture grass for dairy herds and its availability during all seasons of the year.

Average concentrations of alpha and nonvolatile beta emitters found on vegetation collected from each of the circular routes shown in figure 1 are presented in table 5. These results are consistent with the concentrations measured during the third quarter of 1960. The radioiodine concentrations on vegetation samples were less than the minimum sensitivity of the analyses (0.6 μμc/gm).

TABLE 5.—GROSS ALPHA AND BETA CONCENTRATIONS IN GRASS SAMPLES, FOURTH QUARTER 1960

[Average concentrations in μμc/gm dry weight]

Location	Alpha	Nonvolatile beta
Plant boundary	0.14	16
25 mile radius	0.14	14
Sensitivity of analysis	0.10	2

Milk samples were collected on a weekly basis from three dairies (Aiken, North Augusta, and Langley, South Carolina) and two farms (Snelling and Talatha, South Carolina) and analyzed for tritium and radioiodine (primarily iodine-131) content. The quarterly average radioiodine concentration in milk samples was less than the minimum sensitivity of analysis (9 μμc/liter). The quarterly average tritium concentrations in milk were approximately 0.2% of the population MPC.

Strontium-90 content of locally produced milk is determined quarterly. In addition to the sampling points mentioned previously, milk from Wainsboro and Sylvania, Georgia, and New Ellenton, South Carolina, was sampled and analyzed. The concentrations of strontium-90 show no correlation with the distance from the plant and are attributed to fallout debris. The average concentration detected in milk samples from local dairies decreased from 14.5 μμc/liter to 11.6 μμc/liter during the fourth quarter of 1960.

The determination of radioactivity concentrations in algae is important because they are well known concentrators of specific radioactive materials and because of their relationship in the food chain of aquatic organisms. Indigenous algae, primarily green (*Vaucheria*) and blue-green (*Phormidium*), were collected weekly upstream from, adjacent to, and downstream from the plant. The average nonvolatile beta concentration observed in the river algae adjacent to the plant was 333 μμc/gm compared with the downstream average of 182 μμc/gm. Both of these concentrations show some correlation with the plant effluent entry into the river since the average concentrations of nonvolatile beta in algae upstream from the plant was 28 μμc/gm dry weight.

Fish (predominantly bream and catfish) were collected weekly above, adjacent to, and below the plant. The quarterly average nonvolatile beta concentrations measured in the edible portion (flesh) were 5 μμc/gm wet weight upstream from the plant, 6 μμc/gm at the plant boundary, and 5 μμc/gm at the 10 mile downstream sampling location. These concentrations show no plant contribution and are attributed to naturally occurring potassium-40.

General Conclusion

As previously established, concentrations of radioactivity in air show no relationship with plant releases. This conclusion was further demonstrated during the fourth quarter of 1960 by a comparison of atmospheric radioactivity at locations approximately 100 miles from the plant (some distance that the effect of plant operations is minimal) with that at the plant perimeter.

RADIATION EXPOSURE IN THE UNITED STATES

Radiation control programs should give equal consideration to minimize the exposure from all sources of radiation. Emphasis should not be placed on controlling exposure from radioisotopes to the exclusion of controlling exposure from machine-produced radiation. Furthermore, the establishment of an exposure limit should not be interpreted to encourage exposure up to this limit, but rather to keep exposure to a minimum consistent with the benefit received. The following article by Dr. Hanson Blatz discusses his philosophy on these points.

Some Reflections On Current Plans To Control Radiation Exposure In The United States

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For many years, committees of distinguished scientists have been studying the overall effects of radiation exposure on humans and have been making recommendations. The committees include those of the National Academy of Sciences-National Research Council, the Federal Radiation Council, and the United Nations Scientific Committee on the Effects of Atomic Radiation. The report of the Federal Radiation Council states, "there is no necessity for setting the (permissible exposure) level (as high as 5 rems per year) because the doses actually received are generally much less at the present time." This represents the general philosophy of all the committees reporting.

The report of the National Academy of Sciences makes it quite clear, as do other reports, that the major fraction of man's exposure from man-made sources of radiation results from small doses of radiation received by large numbers of the population, rather than those doses being received by radiation workers. The reports of all committees seem to be most concerned with the control of the integrated dose to the gonads of the entire population and also with the statistical effects of small amounts of radiation to large numbers of humans. The report of the Federal Radiation Council states that "every reasonable effort should be made to keep exposures as far below the recommended levels as practicable." It also states that "the degree of control effort should not depend solely on whether or not this guide is being exceeded." In the 1960 report of the National Academy of Sciences it is stated that "the average population exposure to man-made ionizing radiation, including medical radiation, should be not more than ten roentgens to the gonads per reproductive cycle; preferably, it should be less." The British Committee has a similar recommendation.

The records of the Atomic Energy Commission, its contractors and licensees, as well as those of other agencies keeping such records, show that the number of radiation overexposures is remarkably low considering the number of persons using radiation today. The number of radiation injuries is extremely small. This would appear to indicate that no great effort is needed to extend regulation in order to eliminate radiation injuries or keep exposure within the prescribed limits. X-ray injuries in recent years have been notably few in spite of little or no regulation.

A second group of committees has been equally active in enacting and recommending legislation to control radiation exposure. Presumably these committees have been guided by the recommendations of the scientific committees studying radiation effects and by recent experience. A review of the recommended legislation, however, indicates that it deals almost exclusively with the avoidance of the overexposure of radiation workers and individuals in the population. In most cases, there is no provision for the elimination of unnecessary radiation exposure where it is within the prescribed limits set for individuals. In the recent report of Subcommittee No. 10 of the National Committee on Radiation Protection (NCRP), the stated purpose of the recommended legislation is "to reduce, to an acceptable level, the risk that any person will be injured by radiation." In examining the details of the proposed rules, it is found that the regulatory agency is given ample authority to keep routine exposure within the general level of 5 rems per year for each radiation worker and 0.5 rems per year for the general population, but there is no authority to reduce unnecessary radiation exposure unless it exceeds these levels. This appears to be contrary to the needs expressed by the scientific committees who have studied sources of man-made radiation exposure and to recent experience. Neither is there any authority to require modification of facilities or procedures that are found to be likely to result in accidental overexposures.

In the case of the proposed State Radiation Control Act and Regulations prepared by the Council of State Governments, there seems to be a primary consideration for the control of atomic energy materials, whereas it is generally agreed by State and local regulatory agencies that a comprehensive radiation control program to cover all sources is more desirable.

As a result of inspecting many thousands of radiation installations in the City of New York, the most serious deficiency found, in terms of integrated gonadal dose in the population, is the fact that well over 50 percent of all X-ray machines used for taking chest X-rays unnecessarily expose the gonads of the patients to at least 100 times as much radiation as is actually necessary in order to take a satisfactory film. Similar conditions have been found in the medical and dental X-ray examinations of other parts of the body. An interesting fact is that in order to control such radiation exposure, very little effort or expense is involved on the part of those who are responsible for the use of the equipment, but the authority to require the necessary changes is important. The physicians and dentists involved have shown little reluctance to comply with the New York City regulation requiring filtration and the limitation of X-ray beam size, although they had not corrected the deficiencies voluntarily in spite of over twelve years of publicized recommendations by the NCRP, affiliated medical societies, and the Public Health Service. The propsed regulations of Subcommittee No. 10 of the NCRP do not permit an agency authority to correct such sources of unnecessary radiation to the population.

Similarly, experience shows that there seems to be considerable carelessness in the handling of medical and industrial radium sources, to the extent that those individuals working with such sources undoubtedly receive considerably more radiation exposure than necessary, although they are not necessarily overexposed in terms of the prescribed limits.

Careful examination of many recently enacted State and local regulations shows a similar concern with avoiding overexposure and a lack of concern with the control of unnecessary exposure if it is within the prescribed limits. A few states, including Connecticut, Michigan, New York, and Pennsylvania, do have specific provisions for minimizing exposures, but the majority of states do not.

It is considered that there are over 5,000 chest X-ray examinations and probably 50,000 to 75,000 other X-ray examinations made in New York City every day, and about twenty times as many in the entire country. Thus, it would appear that a very large segment of the population dose could be substantially reduced if the codes being proposed and enacted included specific provisions for minimizing exposure.

In addition to preventing unnecessary exposure, radiation regulations should provide authority to guard against accidents which could result in serious overexposures to individuals or to populations. The regulations proposed by NCRP Subcommittee No. 10 do not appear to give either general or specific authority to review or correct hazardous conditions or procedures until there has been overexposure (except for the fire and earthquake provisions in the storage of radioactive materials and the possible spread of contamination, Sections 10 and 11).

Radium-226 In Bovine Bones and Teeth[1]

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Twenty-five bovine jawbones with teeth were collected from different States through the help of the U.S. Army Veterinary Service which furnished data on age, breed, diet, place and time of pasture. The samples were identified by numbers according to the time they were received, but for this study they are listed according to the point of origin. They are assigned to three groups corresponding to the western, central, and eastern regions of the United States.

Toothless portions of the jawbone and second or third premolars were used for the analyses unless these teeth were not available. The bones, ashed at 620°C, and the teeth at 1000°C, were dissolved in nitric acid and analyzed for radium-226 (Ra^{226}) content by the radon emanation technique (*1, 2*).

At least two determinations were made on each sample, and they agreed consistently to within ± 3.0 percent. Since the value of blank determinations was of the order of 0.01 $\mu\mu g$ Ra^{226}, an insignificant amount compared with that in the total sample, no blank correction has been made in the calculations.

The results of the analyses are shown in tables 1, 2, and 3, with the calculated ratio of the concentrations in bone and teeth. The average value for the radium content in bone is the highest in the eastern region (1.197 $\mu\mu g/g$ ash) and the lowest is in the western region (0.250 $\mu\mu g/g$ ash). The samples of the central region with an average value of 0.377 $\mu\mu g/g$ ash, show the greatest uniformity of radium content. The average value for the eastern region does not include a horse sample (14C), which has a very low radium content. Results of additional analyses performed in order to check the data obtained previously

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[1] Reported in *Semi Annual Report*, ANL-6199, January-June 1960, Argonne National Laboratory, Radiological Physics Division.

are shown in parentheses in tables 1, 2, and 3. The agreement between the results is significantly higher for the bone analyses, with a maximum discrepancy of 16%.

Although final conclusions await the result of further analyses, it appears that the greater discrepancies noted in some teeth can be linked with placental discrimination against radium transfer to the newborn (affecting the radium content of teeth partially formed at birth) and subsequent dietary changes concomitant with tooth eruption and calcification (*3, 4*).

For the moment it is worth noting that, in general, the results of this study show agreement between Ra^{226} content of ashed bones and teeth formed after weaning age. The graphical representation of results in figure 1 shows points scattered around a straight line representing a ratio equal to 1; the average value of the ratios of Ra^{226} in bones and teeth, as given in tables 1, 2, and 3 is 1.03 ± 0.2. It is evident that the ratio, constantly close to 1, is not a function of the radium concentration if the analysis is confined to the second or third premolar tooth, even though the absolute concentration in bone varies by a factor of twenty. The fact that such good agreement exists between the radium content in teeth and bones indicates the potential usefulness of Ra^{226} analyses of teeth for the estimation of body burden; it must be noted, however, that this usefulness is predicated upon knowledge of animal history and proper selection of the tooth specimen.

The results of analyses of other radioelements in such samples will be reported later.

TABLE 1.—RADIUM-226 CONTENT OF BOVINE BONES AND TEETH, WESTERN REGION

Location and age	$\mu\mu g$ Ra^{226}/g ash [1]			Ra^{226} ratio (Bone/ tooth)
	Bone	Tooth		
		Code [2]	Value	
Spokane, Wash. 4 yrs. 7 mos.	0.380	P3 P2	0.380 (0.341)	1.00
Inland Emp., Wash. 3 yrs.	0.270	P2	0.220	1.23
Elk Grove, Cal. 17 yrs.	0.185	P2	0.221	0.84
Elk Grove, Cal. 17 yrs.	0.191	P3	0.244	0.78
Salt Lake City, Utah 10 yrs.	0.232	P2	0.261	0.89
Anthony, N.Mex. 6 yrs.	0.245	P2	0.286	0.86
Average	0.250			

[1] Average value of two or more analyses; range of estimated error = ±0.006-0.02 $\mu\mu g$/g ash; results of additional analyses in parentheses.

[2] Code:
DP2 = second deciduous premolar
DP3 = third deciduous premolar
I3 = third permanent incisor
I4c = 4 mm slice cut at the extremity of the crown
I4r = tip of the root (6 mm)
M1 = first molar
P2 = second permanent premolar
P3 = third permanent premolar.

TABLE 2.—RADIUM-226 CONTENT OF BOVINE BONES AND TEETH, CENTRAL REGION

Location and age	$\mu\mu g$ Ra^{226}/g ash [1]			Ra^{226} ratio (Bone/ tooth)
	Bone	Tooth		
		Code [2]	Value	
Cogswell, N. Dak. 7 yrs.	0.327	P3	0.370	0.88
White Bear, Minn. 5 yrs.	(0.288) (0.247)			
Glyndon, Minn. 3 yrs.	0.331	DP3	0.253	1.30
Zumbro Valley, Minn. 7 yrs.	0.333	P3	0.370	0.90
Omaha, Neb. aged cow	0.414 (0.398)	P3	0.467	0.88
Lyndon, Kans. 6 yrs.	0.389	P2	0.340	1.14
Lyndon, Kans. 5 yrs.	0.431 (0.430)	P3 P2	0.485 (0.621)	0.88
Lyndon, Kans. 5 yrs.	0.483 (0.508)	P2 M1	0.293 (0.226)	1.60
Wellston, Okla. 6 yrs.	0.333	P3 P2	0.329 (0.299)	1.01
Shawnee, Okla. 5 yrs.	0.396 (0.386)	P3 P2	0.449 (0.563)	0.88
Amarillo, Tex. 3 yrs.	0.405	P2	0.426	0.95
Chicago, Ill. 5 yrs.	0.395	P3 Not erupted molar	0.364 (0.235)	1.08
Average	0.377			

[1] Average value of two or more analyses; range of estimated error = ±0.006-0.02 $\mu\mu g$/g ash; results of additional analyses in parentheses.

[2] Code:
DP2 = second deciduous premolar
DP3 = third deciduous premolar
I3 = third permanent incisor
I4c = 4 mm slice cut at the extremity of the crown
I4r = tip of the root (6 mm)
M1 = first molar
P2 = second permanent premolar
P3 = third permanent premolar.

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TABLE 3.—RADIUM-226 CONTENT OF BOVINE BONES AND TEETH, EASTERN REGION

Location and age	$\mu\mu g$ Ra^{226}/g ash [1]			Ra^{226} ratio (Bone/tooth)
	Bone	Tooth		
		Code [2]	Value	
Columbus, Ohio 2 yrs.	0.511	DP3 DP2	0.448 (0.429)	1.14
Wapakoneta, Ohio 2 yrs. 6 mos.	0.526	DP2 DP3	0.415 (0.488)	1.26
Augusta, Ga. 8 yrs.	0.973	I3	0.865	1.12
Augusta, Ga.[3] 5 yrs.	2.58	I3 M1 14c 14r	2.16 (0.800) (2.35) (3.53)	1.19
Fayetteville, N.C. 2 yrs.	1.345	DP2	1.20	1.11
Fayetteville, N.C. 1 yr.	1.25	M1	1.68	0.74
Charleston, S.C.[4] 9 yrs.	0.136		0.141	0.96
Average.............	1.197			

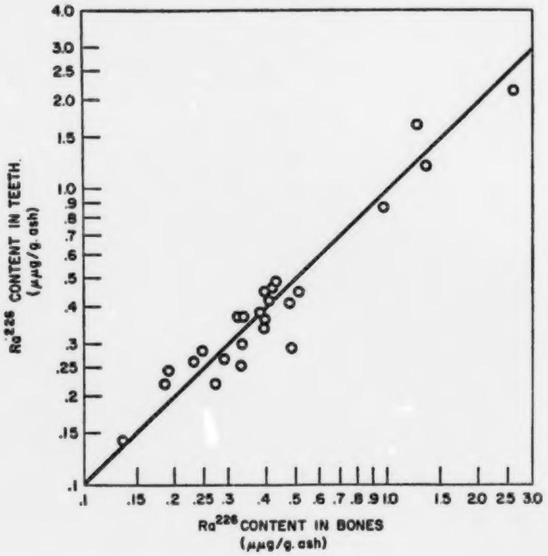
[1] Average value of two or more analyses; range of estimated error = ±0.006-0.02 $\mu\mu g$/g ash: results of additional analyses in parentheses.

[2] Code:
DP2 = second deciduous premolar
DP3 = third deciduous premolar
I3 = third permanent incisor
14c = 4 mm slice cut at the extremity of the crown
14r = tip of the root (6 mm)
M1 = first molar
P2 = second permanent premolar
P3 = third permanent premolar.

[3] The unusually high content in this sample has been verified and confirmed by gamma-spectrum scintillation counting.

[4] Horse sample.

FIGURE 1.—Ra^{226} CONTENT OF BOVINE BONES AND TEETH



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SECTION I. — AIR

Radiation Surveillance Network

Division of Radiological Health, Public Health Service

The Public Health Service Radiation Surveillance Network was established in 1956 in cooperation with the Atomic Energy Commission to provide a means of promptly determining increases in levels of environmental radioactivity due to fallout from nuclear weapons tests. Although no nuclear tests have been conducted by the United States since 1958, the program has proved sufficiently valuable that it has been extended to a year-round basis. Currently, it consists of 45 stations at urban locations (see figure 1) operated by State and local health department personnel with 2 of the stations operated by Public Health Service personnel.

Measurements of gross beta radioactivity in air have been taken since they provide one of the earliest and most sensitive indications of increases of activity in the environment and thus act as an "alert" system. A direct evaluation of biological hazards is not possible from these data alone. Field measurements enable the operator to estimate the amount of beta activity of particulates in air at the station five hours after collection by comparison with a known source using a portable survey meter. The filters are then forwarded to the central laboratory of the Radiation Surveillance Network in Washington, D.C., for a more refined measurement using a thin window proportional counter. The station located at Atlanta, Georgia, conducts its own analyses.

Air samplers are in operation at the 45 stations on an average of 70 percent of the week. Air is drawn through a cellulose carbon-loaded dust filter using a high volume air sampler. The radioactive material in fallout adhering to small particles is retained on the filter. Some gaseous fission products are adsorbed by the carbon. The contribution by gaseous fission products has represented only a small part of the total beta activity in these samples. About 85 percent of the stations collect samples of precipitation which are sent to Washington, D.C., for analysis. Values are now below limits of detection by present instrumentation.

Table 1 summarizes the data for April 1961.

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FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS

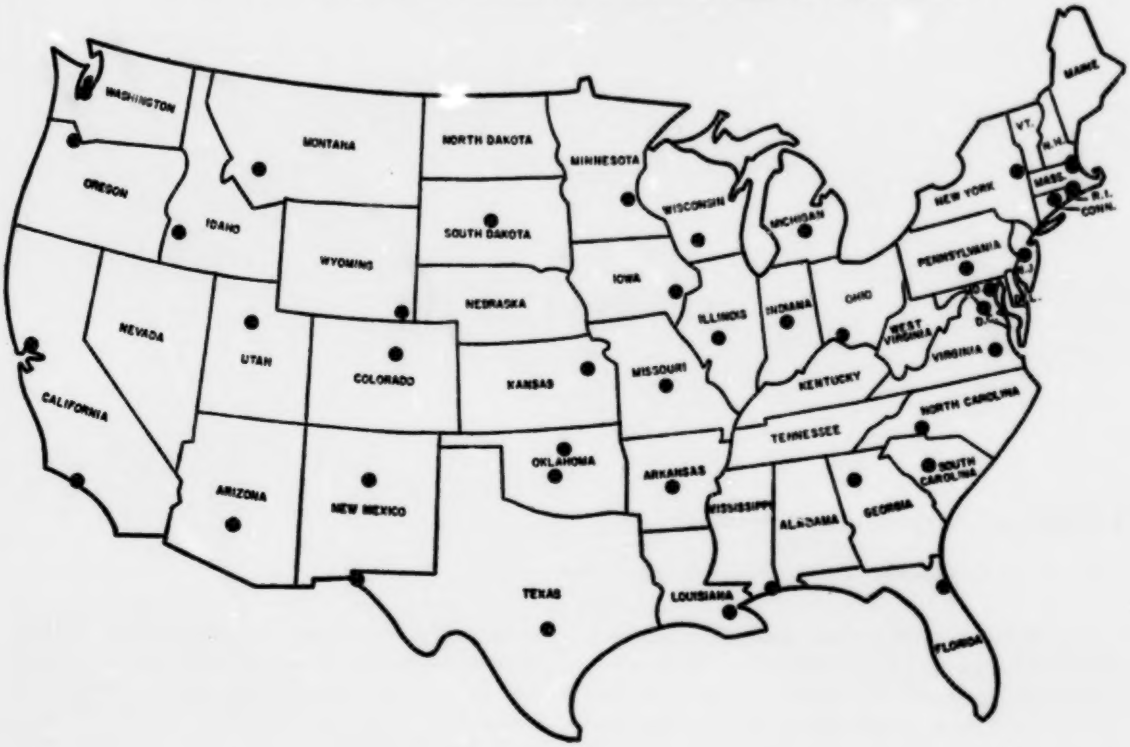

TABLE 1.—RADIOACTIVITY OF PARTICULATES IN AIR-GROSS BETA DETERMINATIONS, APRIL 1961

Station location	Number of samples	Maximum (μμc/m³)	Minimum (μμc/m³)	Average (μμc/m³)	Station location	Number of samples	Maximum (μμc/m³)	Minimum (μμc/m³)	Average [1] (μμc/m³)
Anchorage, Alaska	19	0.14	<0.10	<0.10	Minneapolis, Minn	8	0.15	<0.10	<0.11
Fairbanks, Alaska	20	0.18	<0.10	<0.11	Pascagoula, Miss	19	0.27	<0.10	<0.16
Juneau, Alaska	17	0.14	<0.10	<0.11	Jefferson City, Mo	19	0.21	<0.10	<0.12
Phoenix, Ariz	4	0.26	<0.10	<0.19	Helena, Mont	20	0.25	<0.10	<0.13
Little Rock, Ark	20	0.26	<0.10	<0.14	Trenton, N. J	18	0.30	<0.10	<0.13
Berkeley, Calif	20	0.24	<0.10	<0.12	Santa Fe, N. Mex	16	0.40	<0.10	<0.20
Los Angeles, Calif	19	0.17	<0.10	<0.13	Albany, N. Y	27	0.15	<0.10	<0.10
Denver, Colo	16	0.16	<0.10	<0.12	Gastonia, N. C	18	0.20	<0.10	<0.14
Hartford, Conn	26	0.23	<0.10	<0.11	Oklahoma City, Okla	16	0.20	<0.10	<0.14
District of Columbia	23	0.24	<0.10	<0.12	Ponca City, Okla	20	0.20	<0.10	<0.11
Jacksonville, Fla	19	0.22	<0.10	<0.13	Portland, Oreg	19	0.25	<0.10	<0.14
Atlanta, Ga	11	0.30	<0.10	<0.12	Harrisburg, Pa	12	0.15	<0.10	<0.12
Honolulu, Hawaii	20	0.17	<0.10	<0.10	Providence, R. I	20	0.23	<0.10	<0.12
Boise, Idaho	6	0.19	<0.10	<0.14	Columbia, S. C	6	0.16	<0.10	<0.14
Springfield, Ill	8	0.14	<0.10	<0.11	Pierre, S. Dak	5	0.20	<0.10	<0.12
Indianapolis, Ind	30	0.16	<0.10	<0.11	Austin, Tex	19	0.23	<0.10	<0.14
Iowa City, Iowa	19	0.19	<0.10	<0.13	El Paso, Tex	15	0.80	0.17	0.30
Topeka, Kans	20	0.20	<0.10	<0.12	Salt Lake City, Utah	30	0.20	<0.10	<0.12
New Orleans, La	2	0.10	<0.10	<0.10	Richmond, Va	19	0.14	<0.10	<0.11
Baltimore, Md	20	0.19	<0.10	<0.12	Seattle, Wash	20	0.11	<0.10	<0.10
Lawrence, Mass	18	0.11	<0.10	<0.10	Madison, Wis	30	0.20	<0.10	<0.11
Lansing, Mich	30	0.21	<0.10	<0.12	Cheyenne, Wyo	8	0.13	<0.10	<0.11

[1] Weighted average obtained by summing the products of individual sampling times and the corresponding activities, and dividing by the summation of the individual sampling times.

Surface Air Radon, Thoron and Fission Product Gross Beta Concentrations At Cincinnati, Ohio

Robert A. Taft Sanitary Engineering Center, Public Health Service

Natural background radioactivity in our atmosphere is an important public health consideration because the exposure levels from natural radiation can be used as a base for comparative evaluations of exposures from artificially produced radionuclides. Natural radioactivity in surface air is due to a number of unstable nuclides other than those produced by man. The earth's crust contains trace amounts of uranium and thorium that occur naturally and which decay through a series of their daughter products. These decay products of uranium and thorium are introduced into surface air through their rare gas daughters, radon (radon-222) and thoron (radon-220), which in turn continue to decay through the uranium and thorium series, respectively. The radon and thoron content of air depends on the escape of these rare radioactive gases from the earth. Concentrations depend on prevailing atmospheric conditions such as ambient temperature, humidity, and pressure and on soil conditions such as moisture, porosity, and temperature.

Most of the natural radioactivity in surface air is due to radon (Rn^{222}) and its daughters. Thoron (Rn^{220}) and its daughters contribute much less because of thoron's short half-life and hence, a lower diffusion rate from the soil.

The Radiological Health Research Activities, Research Branch, Division of Radiological Health, Public Health Service, performs a continuous daily sampling program for radon (Rn^{222}) thoron (Rn^{220}), and gross beta fission product concentrations in surface air. The gross beta activity of atmospheric particulates, when measured several days after sample collection, is principally due to artificially produced radionuclides.

Air is filtered through a membrane filter, and the daughter products of radon and thoron, which are particulates, are deposited on the filter. Measurements of the alpha activity on the filter are related to the concentrations of radon or thoron in surface air. Most of the activity of radon daughters, that have a composite half-life of approximately 0.5 hour, would decay to 0.5 per cent of the original value in less than four hours. The activity of thoron daughters that have a composite half-life of 10.6 hours, would decay to 0.5 per cent of its original value in about four days. For this reason the gross beta determinations are made at least four days after the end of each sampling period.

There has been a recent change in the reporting period because the data is now computed by an electronic data processing system, which is programmed for thirteen four-week periods per calendar year.

The data for the period March 27-May 19, 1961 are presented in table 1.

TABLE 1.—RADON, THORON, AND FISSION PRODUCT GROSS BETA CONCENTRATIONS, MARCH 27–MAY 19, 1961

End of sampling period	Continuous sample collection			Radon[a] a.m. (μμc/m^3)	Radon-thoron[b] p.m. (μμc/m^3)	Thoron[c] (μμc/m^3)	Beta[d] activity (μμc/m^3)	End of sampling period	Continuous sample collection			Radon[e] a.m. (μμc/m^3)	Radon-thoron[f] p.m. (μμc/m^3)	Thoron[g] (μμc/m^3	Beta[h] activity (μμc/m^3)
	Sample change time	Sample period (hours)	Volume (m^3)						Sample change time	Sample period (hours)	Volume (m^3)				
Mar. 27...	0819	71.9	71.1	200	90	3.4	0.07	Apr. 24...	0810	72.0	84.0	180	100	1.8	0.09
28...	0810	23.8	29.1	190	70	1.5	0.11	25...	0802	23.9	28.3	90	30	1.2	0.21
29...	0803	23.9	30.4	110	120	1.3	0.00	26...	0816	24.2	29.0	90	80	0.7	0.0[illegible]
30...	0800	23.9	29.8	100	90	1.3	0.04	27...	0815	23.9	29.1	140	60	1.6	0.07
31...	0812	23.6	30.5	180	40	1.3	0.08	28...	0806	23.7	28.3	130	50	1.9	0.13
Apr. 3...	0805	71.9	89.6	340	170	3.1	0.10	May 1...	0814	72.1	86.1	300	60	3.8	0.10
4...	0803	24.0	29.2	150	100	1.3	0.11	2...	0807	23.9	28.4	250	100	2.3	0.14
5...	0810	24.1	29.3	300	40	5.2	0.10	3...	0813	24.1	28.6	590	30	4.5	0.16
6...	0804	23.9	28.9	120	110	2.0	0.08	4...	0815	24.0	28.7	540	50	5.4	0.11
7...	0801	23.9	29.4	190	90	3.1	0.54	5...	0828	24.1	29.0	160	40	2.6	0.09
10...	0805	72.1	87.4	100	80	1.4	0.04	8...	0815	71.8	85.9	70	100	0.4	0.00
11...	0808	24.0	28.5	210	50	1.7	0.01	9...	0803	23.8	28.6	50	90	0.1	0.16
12...	0813	24.1	28.0	80	30	0.9	0.10	10...	0805	24.0	28.9	90	80	0.6	0.12
13...	0815	24.0	27.8	60	70	0.7	0.08	11...	0806	24.0	29.3	70	50	0.9	0.12
14...	0807	23.8	28.0	160	30	1.6	0.01	12...	0810	24.0	29.1	150	90	1.3	0.13
17...	0800	71.9	85.5	80	50	1.2	0.08	15...	0800	63.8	76.9	100	60	2.8	0.15
18...	0811	24.2	28.9	110	80	0.9	0.10	16...	0815	24.1	28.5	90	90	1.2	0.03
19...	0800	23.8	28.9	390	50	1.9	0.02	17...	0800	23.7	28.7	160	50	2.4	0.06
20...	0810	24.2	29.5	220	60	1.5	0.12	18...	0810	24.1	29.0	160	50	0.2	0.17
21...	0810	24.0	29.2	120	70	1.5	0.08	19...	0810	24.0	29.2	220	140	2.1	0.13
Average	----------	----------	----------	178	74	1.8	0.09	Average	----------	----------	----------	180	74	1.9	0.11

[a] Radon concentrations are derived from alpha measurements determined immediately after the sampling period (24 to 72 hours) has ceased. Reported radon concentrations have been corrected for any thoron daughter interferences. Twice the standard deviation (2σ) falls between ±16 and ±33 μμc/m^3.

[b] Radon-thoron concentrations are derived from alpha measurements made in the afternoon (3 p.m.) approximately 7 hours after the new sampling period has begun. Therefore, the reported values were actually determined one working day prior to the date reported here. Reported radon concentrations are uncorrected for any thoron daughter interferences. Twice the standard deviation (2σ) falls between ±10 and ±22 μμc/m^3.

[c] Thoron concentrations are derived from alpha measurements referred to in footnote (a) but are counted 7 hours after the sampling period has ceased. Reported values are corrected to the time of removal of the filter holder. Twice the standard deviation (2σ) falls between ±0.3 and ±0.7 μμc/m^3.

[d] Surface air fission product gross beta concentrations are based on measurements made at least 4 days after the end of each sampling period (24 to 72 hours). Twice the standard deviation (2σ) falls between ±0.01 and ±0.05 μμc/m^3.

[e] Radon concentrations are derived from alpha measurements determined immediately after the sampling period (24 to 72) hours has ceased. Reported radon concentrations have been corrected for any thoron daughter interferences. Twice the standard deviation (2σ) falls between ±12 and ±43 μμc/m^3.

[f] Radon-thoron concentrations are derived from alpha measurements made in the afternoon (3 p.m.) approximately 7 hours after the new sampling period has begun. Therefore, the reported values were actually determined one working day prior to the date reported here. Reported radon concentrations are uncorrected for any thoron daughter interferences. Twice the standard deviation (2σ) falls between ±10 and ±22 μμc/m^3.

[g] Thoron concentrations are derived from alpha measurements referred to in footnote (e) but are counted 7 hours after the sampling period has ceased. Reported values are corrected to the time of removal of the filter holder. Twice the stardard deviation (2σ) falls between ±0.2 and ±0.8 μμc/m^3.

[h] Surface air fission product gross beta concentrations are based on measurements made at least 4 days after the end of each sampling period (24 to 72 hours. Twice the standard deviation (2σ) falls between ±0.01 and ±0.05 μμc/m^3.

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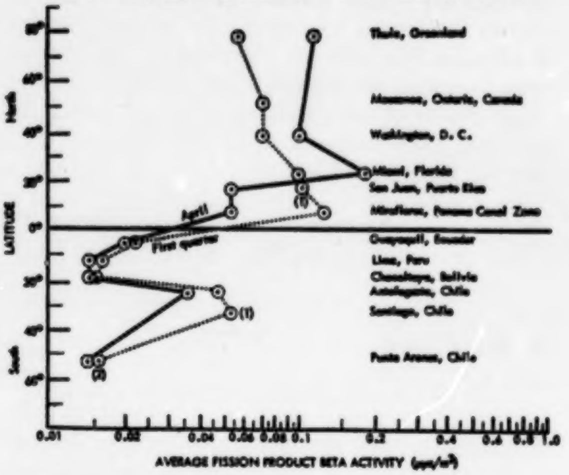
Radioactivity Measurements In Air

U.S. Naval Research Laboratory

Radioactivity measurements of air-filter samples collected at various sites near the 80th Meridian (West) are made by the U.S. Naval Research Laboratory under a program partially financed by the Atomic Energy Commission.

The daily record of fission product beta activity during April 1961 is presented in table 1, and the radioactivity profile for the same month and the first quarter 1961 are shown in figure 1. This figure illustrates the data plotted in semilogarithmic coordinates. The ordinate is expressed in micromicrocuries per cubic meter of surface air. The concentrations in table 1 are expressed in disintegrations per minute per cubic meter of air at the collecting site (2.2 disintegrations per minute per cubic meter equals 1 micromicrocurie per cubic meter).

FIGURE 1.—PROFILE OF BETA ACTIVITY, AVERAGE MEASUREMENTS OF SURFACE AIR AT STATIONS NEAR THE 80TH MERIDIAN (WEST), FIRST QUARTER AND APRIL 1961



(1) Average based on one month.
(2) Average based on two months.

TABLE 1.—DAILY RECORD OF FISSION PRODUCT BETA ACTIVITY COLLECTED BY AIR FILTRATION, APRIL 1961

[Disintegrations per minute/cubic meter]

Day	Punta Arenas, Chile	Antofagasta, Chile	Chacaltaya, Bolivia	Lima, Peru	Guayaquil, Ecuador	Miraflores, Panama Canal Zone	San Juan, Puerto Rico	Mauna Loa, Hawaii	Miami, Florida	Washington, D.C.	Thule, Greenland
1	0.02	0.06	0.01	0.02	0.05	0.06	----------	0.18	0.30	0.26	0.25
2	0.02	0.06	0.01	0.02	0.04	0.06	----------	0.18	0.30	0.26	0.25
3	0.02	0.06	0.01	0.02	0.06	0.06	----------	0.18	0.30	0.26	0.25
4	0.02	----------	0.05	0.04	0.05	0.06	----------	0.25	0.47	0.19	0.08
5	0.02	----------	0.05	0.04	0.03	0.06	----------	0.25	0.47	0.19	0.08
6	0.02	0.05	0.03	0.04	0.04	0.12	----------	0.14	0.55	0.17	0.20
7	0.02	0.05	0.03	0.04	0.04	0.12	----------	0.14	0.55	0.17	0.20
8	0.02	0.16	0.03	0.04	0.05	0.13	----------	0.06	0.29	0.19	0.31
9	0.02	0.16	0.03	0.04	0.07	0.13	----------	0.06	0.29	0.19	0.31
10	0.02	0.16	0.03	0.04	0.11	0.13	0.08	0.06	0.29	0.19	0.17
11	0.03	0.04	0.05	0.03	0.03	0.14	0.08	0.06	0.24	0.08	0.17
12	0.03	0.04	0.05	0.03	0.05	0.14	0.08	0.06	0.24	0.08	0.17
13	0.03	0.07	0.02	0.03	0.05	0.12	0.16	0.28	0.28	0.10	0.43
14	0.03	0.07	0.02	0.03	0.05	0.12	0.16	0.28	0.28	0.10	0.43
15	0.04	0.07	0.01	0.01	0.04	0.14	0.09	0.13	0.24	0.31	0.34
16	0.04	0.07	0.01	0.01	0.06	0.14	0.09	0.13	0.24	0.31	0.34
17	0.04	0.07	0.01	0.01	0.03	0.14	0.09	0.13	0.24	0.31	0.34
18	0.06	0.05	0.02	0.05	0.03	0.15	0.11	0.12	0.47	0.18	0.22
19	0.06	0.05	0.02	0.05	0.03	0.15	0.11	0.12	0.47	0.18	0.22
20	0.06	0.05	0.04	0.02	0.03	0.14	0.13	0.13	0.46	0.22	0.21
21	0.06	0.05	0.04	0.02	0.03	0.14	0.13	0.13	0.46	0.22	0.21
22	0.03	0.07	0.03	0.03	0.05	0.11	0.12	0.39	0.53	0.22	0.33
23	0.03	0.07	0.03	0.03	0.04	0.11	0.12	0.39	0.53	0.22	0.33
24	0.03	0.07	0.03	0.03	0.04	0.11	0.12	0.39	0.53	0.22	0.33
25	----------	0.07	0.02	0.06	0.08	0.12	0.16	0.33	0.63	0.45	0.26
26	----------	0.07	0.02	0.06	0.05	0.12	0.16	0.33	0.63	0.45	0.26
27	----------	0.09	0.07	0.03	0.04	0.12	0.05	0.39	0.50	0.28	0.30
28	----------	0.09	0.07	0.03	0.06	0.12	0.06	0.39	0.50	0.28	0.30
29	----------	0.10	0.03	0.04	0.05	0.11	0.21	0.12	0.48	0.29	0.23
30	----------	0.10	0.03	0.04	0.05	0.11	0.21	0.12	0.48	0.29	0.23
Mean (dpm/m³)	0.03	0.08	0.02	0.03	0.05	0.12	0.12	0.20	0.41	0.23	0.26
Mean (μμc/m³)	0.014	0.034	0.014	0.014	0.022	0.054	0.054	0.090	0.185	0.104	0.117

SAMPLING PROGRAMS FOR RADIOACTIVITY IN AIR

The following article is the second in a series of discussions intended to present summaries of atmospheric levels of radioactivity. The first article, which appeared in *Radiological Health Data,* Vol. II, No. 8, summarized the results of surface air fission product gross beta measurements conducted by the Public Health Service Radiation Surveillance Network. This discussion summarizes similar data collected by the U.S. Naval Research Laboratory at carefully selected sites near the 80th meridian (West) during the period 1958-1960.

The presentation and illustrations were compiled by Messrs. Roscoe H. Goeke, John G. Bailey, and Andreas P. Zizos of the Data Collation and Analysis Unit, Division of Radiological Health, Public Health Service. The authors wish to express their appreciation to Dr. Luther B. Lockhart, Jr. of the U.S. Naval Research Laboratory for supplying the basic data and assistance in preparing this presentation, and to the staff of the Atmospheric Radioactivity Research Project, U.S. Weather Bureau, for their review of the text.

Surface Air Gross Beta Fission Product Concentrations Near The 80th Meridian (West) During 1958-1960

Compiled by Division of Radiological Health, Public Health Service

Introduction

In 1956 the U.S. Naval Research Laboratory, with the assistance of the U.S. Atomic Energy Commission, the U.S. Weather Bureau, and interested groups in Canada and South America, initiated a program for measuring the fission product radioactivity in air at a carefully selected group of sites near the 80th meridian. During 1957, this program was expanded to include collections at several other locations which were of interest to the U.S. Air Force Cambridge Research Center. In 1958, this work was carried out as part of the International Geophysical Year Program on Atmospheric Nuclear Radiation. Sampling continued during 1959 as part of the International Geophysical Cooperation-1959 Program. The Network continued operations during 1960 with a reduction in the number of collection sites. The program has been partially financed since 1956 by the Division of Biology and Medicine, U.S. Atomic Energy Commission.

All gross beta samples from a given station were combined at the end of each month, and radiochemical analyses were conducted for Sr^{89}, Sr^{90}, Y^{91}, Cs^{137}, Ce^{141}, Ce^{144}, and occasionally for Pb^{210}. In 1958, the analytical scheme was modified so the W^{185} could be isolated from the samples. Subsequently, analyses for Pb^{210} were discontinued because the W^{185} procedure interfered with the recovery of Pb^{210}.

Figure 1 illustrates the geographic distribution of the collecting sites, and table 1 presents their respective coordinates, elevation, sampling frequency, and operating agency.

FIGURE 1.—ATMOSPHERIC RADIOACTIVITY STATIONS NEAR THE 80TH MERIDIAN *(5)*

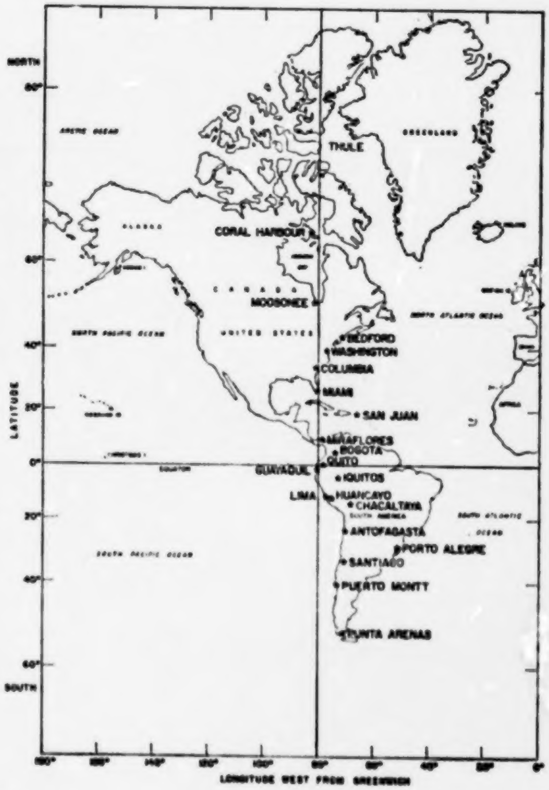


TABLE 1.—COLLECTING SITES ASSOCIATED WITH THE NRL/IGY PROGRAM OF ATMOSPHERIC NUCLEAR RADIATION*(5)*

Station	Latitude	Longitude	Elevation (m)	Operator
Daily Filter Collections				
Thule, Greenland	76°35'N	68°35'W	259	IGY Thule Coordinator, U.S. Air Force
Coral Harbour, N.W.T., Canada	64°12'N	83°22'W	59	Meteorological Branch, Department of Transport (Canada)
Moosonee, Ontario, Canada	51°16'N	80°39'W	10	Meteorological Branch, Department of Transport (Canada)
Bedford, Mass., USA	42°27'N	71°22'W	80	USAF Cambridge Research Center
Silver Hill, Maryland, USA (Washington, D.C.)	38°50'N	76°57'W	88	U.S. Weather Bureau
Columbia, S.C., USA	33°57'N	81°07'W	69	U.S. Weather Bureau
Miami, Florida, USA	25°49'N	80°17'W	4	U.S. Weather Bureau
San Juan, Puerto Rico	18°26'N	66°00'W	10	U.S. Weather Bureau
Miraflores, Panama Canal Zone	9°00'N	79°35'W	10	Canal Zone Corrosion Laboratory, U.S. Naval Research Laboratory
Bogota, Colombia	4°37'N	74°04'W	2640	Instituto Geofisico de los Andes Colombianos
Quito, Ecuador	0°08'S	78°26'W	2818	Astronomic Observatory
Guayaquil, Ecuador	2°10'S	79°52'W	7	Meteorological Office
Iquitos, Peru	3°45'S	73°11'W	117	Corporacion Peruana de Aeropuertos y Aviacion Comercial (CORPAC)
Lima, Peru	12°06'S	77°01'W	134	Corporacion Peruana de Aeropuertos y Aviacion Comercial (CORPAC)
Huancayo, Peru	12°07'S	75°20'W	3353	Instituto Geofisico de Huancayo
Chacaltaya, Bolivia	17°10'S	68°15'W	5220	Universidad Mayor de San Andres, Laboratorio de Fisica Cosmica de Chacaltaya
Antofagasta, Chile	23°37'S	70°16'W	519	NASA Satellite Tracking Station
Porto Alegre, Brazil	30°02'S	51°13'W	24	Servico de Meteorologia
Santiago, Chile	33°27'S	70°42'W	520	Oficina Meteorologica de Chile
Puerto Montt, Chile	41°27'S	72°57'W	5	U.S. Weather Bureau
Punta Arenas, Chile	53°08'S	70°53'W	3	Oficina Meteorologica de Chile
Weekly Filter Collections				
Drifting Station Alpha [1]	83°-86°N	110°-180°W	3	U.S. Weather Bureau/IGY
Muana Loa, Hawaii, Hawaii	19°28'N	155°36'W	3394	U.S. Weather Bureau/IGY
Pearl Harbor, Oahu, Hawaii	21°22'N	157°58'W	5	U.S. Naval Air Station, Ford Island
Subic Bay, Philippines	14°49'N	120°17'E	18	U.S. Naval Station, Subic Bay

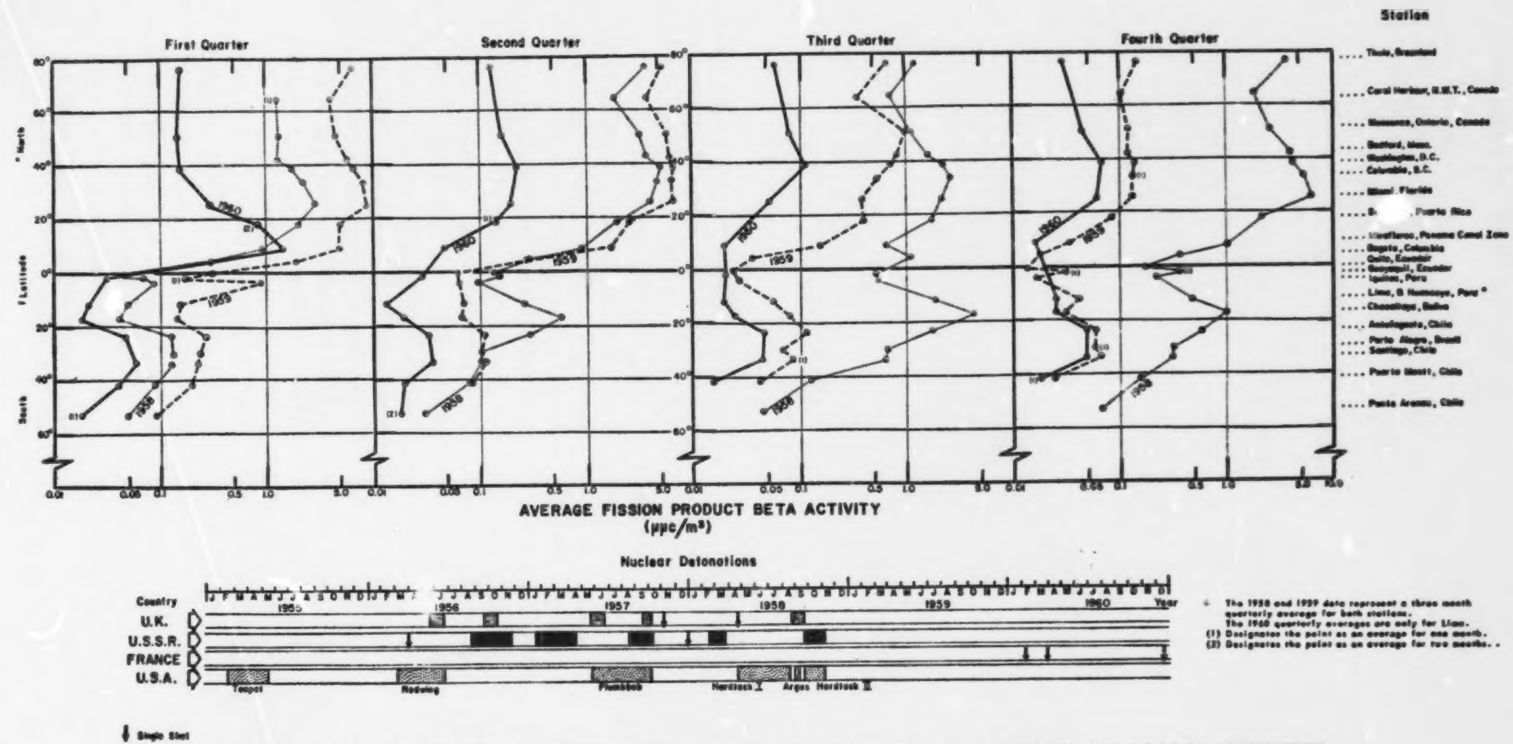
[1] Station evacuated November 1, 1958.

Summary of Results, 1958-1960

Figure 2 presents quarterly profiles of surface air fission product gross beta measurements conducted at stations near the 80th meridian (West). The basic data used in preparing this illustration was supplied by the U.S. Naval Research Laboratory. Starting with the first quarter of 1958, and proceeding to the second quarter of that year, one finds an overall increase in the atmospheric concentrations for both the Northern and Southern Hemispheres, but the third quarter's data indicate an unusual condition. In this case, the Northern Hemisphere's peak has decreased somewhat, while the Southern Hemisphere's peak exceeds that of the Northern Hemisphere for the first and only time. During the last quarter of 1958, the Northern Hemisphere's profile appears to be somewhat similar to the one shown for the second quarter of that year, and the Southern Hemisphere's profile appears to have decreased to a level between the ones shown for the second and third quarters of that year.

In the first and second quarters of 1959, the Northern Hemisphere's profiles exemplify the highest maxima since the conception of this network in 1956. The Southern Hemisphere's profile for the first quarter has exceeded that for the same period in 1958, while its profile during the second quarter is below that for the corresponding period of the previous year. Notice that during the third and fourth quarters of 1959, both the Northern and Southern Hemispheres show a drastic reduction in their ground-level concentration when compared to the profiles for the second quarter of 1959 and the third and fourth quarters of 1958.

During the first quarter of 1960 there appears a rather marked rise between 0° and 20° latitude (North), and a situation for the Southern Hemisphere which is not very dissimilar to the one which occurs during the fourth quarter of 1959. During the second, third, and fourth quarters of 1960, the Northern Hemisphere exemplifies a gradual decrease, while the Southern Hemisphere does not change markedly. In fact, the maxima for both the Northern and Southern Hemispheres are approximately the same.



* The 1958 and 1959 data represent a three month quarterly average for both stations.
The 1960 quarterly averages are only for Lima.
(1) Designates the point as an average for one month.
(2) Designates the point as an average for two months.

FIGURE 2.—PROFILE OF BETA ACTIVITY, QUARTERLY RESULTS OF SURFACE AIR MEASUREMENTS CONDUCTED AT STATIONS NEAR THE 80TH MERIDIAN

The effects of nuclear tests are readily noted by increases in surface air fission product gross beta concentrations in the Northern Hemisphere during the Soviet tests of February and March 1958, whose effects lasted well into June, and the Soviet tests from 30 September through 3 November 1958, where the effects were strong throughout the remainder of 1958 and well into 1959. Neither of the United States' test series of 1958 had a relatively large effect on this hemisphere, although the presence of debris from the Pacific tests of April-July (Operation Hardtack, Phase I) were detected through the W^{185} isotope produced in this series of tests as a tracer (7). During January-April 1958, no tests occurred south of the Equator. Therefore, low activities were encountered in spite of the high activities prevalent in the Northern Hemisphere. The Southern peak starting to form in the second quarter of 1958 may have been due, in part, to the April United Kingdom detonation at Christmas Island, although large amounts of the W^{185} tracer identified a considerable portion of this activity as debris arising from the United States Pacific tests (7). Radiochemical data, not presented here, may help to explain the unusual situation noted in the Southern Hemisphere during the third quarter of 1958 (7). These data have indicated that at least two bulk exchanges of air between hemispheres occurred during May-July 1958. It appears likely that this new debris was transported by upper tropospheric winds during the Hardtack series in the Pacific (1958).

During 1959, no fresh debris was added to the atmosphere. The maxima which appear in the Northern Hemisphere during the first and second quarters of that year are undoubtedly attributable primarily to the fall 1958 USSR series. Monthly fission product gross beta measurements conducted in the Northern Hemisphere indicate sudden drops after May 1959 with a maximum residence time of 30 days for tropospheric debris. These conclusions are confirmed by the radio-chemical data (3).

The large peak between 0° and 20° latitude (North) during the first quarter of 1960 is, without question, due to the French detonation on 13 February. The second French detonation of 1 April is not easily seen in the second quarter's data. This is due to the small yield of this device and to the fact that the background of radioactivity had risen as a result of the seasonal increase in stratospheric deposition. Note that with the exception of that region between approximately 0° and 10° latitude (South), the Southern Hemispheric profiles have not changed considerably.

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(2) Joint Committee on Atomic Energy, Congressional Hearings on Radioactive Fallout, 1957, 1959.

(3) L. B. Lockhart, Jr., R. L. Patterson, Jr., A. W. Saunders, Jr. and R. W. Black, "Fission Product Radioactivity in the Air Along the 80th Meridian (West) During 1959", NRL Report 5528, 15 August 1960. See also J. Geophys. Res. Vol. *65*, No. 12, 3987-97 (Dec. 1960)

(4) L. B. Lockhart, Jr., R. A. Baus, R. L. Patterson, Jr., and A. W. Saunders, Jr., "Radiochemical Analyses of Air Filter Samples Collected During 1958," NRL Report 5390, 1 October 1959.

(5) L. B. Lockhart, Jr., R. L. Patterson, Jr., and W. L. Anderson, "Measurements of the Air Concentration of Gross Fission Product Radioactivity During the IGY, July 1957-December 1958," NRL Report 5359, September 1959.

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(9) L. B. Lockhart, Jr., R. A. Baus, and I. H. Blifford, Jr., "Fission Product Radioactivity in the Air Along the 80th Meridian, January-June 1957," NRL Report 5041, November 1957. See also Tellus, Vol. XI, No. 1, 83-90, 1959.

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(11) NRL Monthly letters Reports "Fission Product Radioactivity of the Air Along the 80th Meridian (West)," (1956-Continuing).

(12) Radioactivity Data Sheets forwarded monthly to IGY World Data Center, Asheville, N. C., 1958-1959.

(13) R. A. Baus, R. L. Patterson, Jr., A. W. Saunders, Jr., and L. B. Lockhart, Jr., "Radiochemical Analyses of Air Filter Samples Collected During 1957," NRL Report 5239, December 1958.

SECTION II. — FOOD, OTHER THAN MILK

Survey of Radioactivity in Food

Food and Drug Administration

The following tabulations present the results of a continuing surveillance of food items, conducted by the Food and Drug Administration (FDA). The FDA's 18 Districts throughout the United States collect and analyze all samples for strontium-90. The following data are the results of analyses conducted on approximately 1500 samples comprising 50 different foods collected in 1960. Table 1 gives results on 6 different vegetables, table 2, the results on 3 different fruits, and table 3, the results on wheat and its derivatives. A trend toward lower concentrations of strontium-90 in fruits, as compared with vegetables, is indicated.

TABLE 1.—STRONTIUM-90 CONTENT OF VEGETABLES, 1960

[Concentration in $\mu\mu c$/kg original material]

Food item	Harvest Date	Area		Strontium-90
		County	State	
Cabbage	September 28	Wayne	N.Y.	19.7
Cabbage	October 10	Madison	Ill.	7.1
Cabbage	25	Ada & Canyon	Idaho	2.0
Celery	September 1	Monterey	Calif.	0.9
Celery	27	Wayne	N.Y.	2.1
Celery	27	Wayne	N.Y.	2.4
Celery	28	Cayuga	N.Y.	1.8
Green beans (canned).	November 16	Hidalgo	Tex.	1.0
Green beans (canned).	16	Hidalgo	Tex.	0.8
Lettuce	August 29	Rio Grande	Colo.	4.0
Lettuce	29	Saquache	Colo.	2.4
Lettuce	30	Alamosa	Colo.	3.5
Lettuce	September 14	Oswego	N.Y.	2.2
Lettuce	21	Oswego	N.Y.	1.1
Lettuce	21	Oswego	N.Y.	5.4
Lettuce	21	Oswego	N.Y.	2.6
Lettuce	22	Oswego	N.Y.	4.5
Lettuce	26	Hamilton	Ohio	5.9
Lettuce	October 8	Marion	Ohio	8.2
Potatoes	August 9	Wayne	N.Y.	4.7
Potatoes	October 3	Canyon	Idaho	1.2
Spinach	4	Genesee	N.Y.	2.9
Spinach (fresh)	4	Wayne	N.Y.	4.4
Spinach (frozen)	4	Wayne	N.Y.	6.7
Spinach	18	Yates	N.Y.	4.0

TABLE 2.—STRONTIUM-90 CONTENT OF FRUITS, 1960

[Concentration in $\mu\mu c$/kg original material]

Food item	Harvest date	Area		Strontium-90
		County	State	
Apples, pulp	September 27	Doniphan	Kans.	0.9
Apples, pulp	27	Lehigh	Pa.	1.8
Apples, pulp	October 6	York	Pa.	1.3
Apples, whole	5	Berks	Pa.	1.0
Apples, whole	7	Washington	Md.	1.0
Apples, whole	20	Utah	Utah	0.6
Peaches, whole	August	Niagara	N.Y.	1.1
Tomatoes, canned	September 19	Niagara	N.Y.	0.9
Tomatoes, canned [1]	23	Chautaugna	N.Y.	0.6
Tomatoes, canned [2]	October 3	Orleans	N.Y.	0.9
Tomatoes, fresh	September 23	Chataqua	N.Y.	1.0
Tomatoes, fresh	October 3	Orleans	N.Y.	1.6

[1] Peeled and canned from fresh Chataqua tomatoes.
[2] Peeled and canned from fresh Orleans tomatoes.

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TABLE 3.—STRONTIUM-90 CONTENT OF WHEAT AND DERIVATIVES

[Concentration in μμc/kg original material]

Food item	Harvest date	Area		Strontium-90
		County	State	
Bran [1]	July 1960	Salano & Moduc	Calif.	13
Bran [2]	July 1960	Anderson & Aconee	S.C.	64
Bran [2]	July 1960	Anderson & Aconee	S.C.	47
Flour [2]	July 1960	Anderson & Aconee	S.C.	6
Wheat	Fall, 1959	Morrow	Oreg.	3.5
Wheat	Fall, 1959	Franklin	Wash.	1.5
Wheat	Fall, 1959	Walla Walla	Wash.	8.1
Wheat	Fall, 1959	Gallatin	Mont.	21
Wheat	Fall, 1959	Pondera	Mont.	18
Wheat	Fall, 1959	Fergus	Mont.	11
Wheat	Fall, 1959	Hill	Mont.	12
Wheat	Fall, 1959	Chotean	Mont.	54
Wheat	June 20, 1960	Solano	Calif.	1.8
Wheat	July 1960	Modoc	Calif.	1.5
Wheat	July 1960	Anderson & Aconee	S.C.	48
Wheat	August 9, 1960	Carver	Minn.	10

[1] Sample prepared from Salano and Moduc wheats.
[2] Sample prepared from Anderson and Aconee wheats.

Estimate Of The Dietary Intake Of Radium-226 For New York City Infants [1]

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U.S. Atomic Energy Commission

For the purpose of estimating the strontium-90 dietary intake of infants in New York City, the Health and Safety Laboratory began a special study in August 1959 to sample and analyze periodically, commercially processed baby foods and milks for strontium-90 and calcium. Results of three semi-annual samplings, as well as a discussion of sample selection and consumption figures, have been reported in previous quarterly reports (1, 2).

The samples collected in August of 1960 were assayed for radium-226, employing the barium chromate fractions obtained during the strontium-90 analysis and the radon-222 emanation method (3). It was assumed that the recovery values determined by strontium-85, could be applied to the radium results. Four blank reagent samples were prepared by running distilled water through the actual sample procedure. The average amount of radium found in the blanks was 0.01 μμc. The lowest amount detected in the food samples was 0.26 μμc. Two emanations and countings performed on each of seven barium chromate solutions, derived from these samples, indicated an average precision of 95 percent for this part of the procedure.

The radium-226, and previously reported calcium data, are presented in table 1. If the assumption is made that the August 1960 radium-226 values are typical, then we calculate the total radium-226 intake of an infant during the first year to be 212 μμc. The radium-226 to calcium ratio of the infant's diet would be 0.65 μμc per gram.

REFERENCES

(1) *Quarterly Summary Report*, HASL-88, July 1, 1960.
(2) *Quarterly Summary Report*, HASL-111, April 1, 1961.
(3) Described in *Quarterly Summary Report*, HASL-113, July 1, 1961, p. 90.

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[1] Reported in *Quarterly Summary Report*, HASL-113, July 1, 1961.

TABLE 1.—RADIUM-226 AND CALCIUM IN THE DIET OF AN INFANT FOR HIS FIRST YEAR OF LIFE

[Based on foods sampled in August 1960]

Type of food	Quantities consumed (kg)	Radium-226			Total consumed	
		gmCa/kg original material	μμc/kg original material	μμc/gm Ca	Ra 226 (μμc)	Calcium (gm)
Cereals	8	8.22	14.3	1.7	114	66
Vegetables	23	0.29	0.59	2.0	14	7
Fruits	23	0.08	0.44	5.5	10	2
Meats	17	0.12	0.43	3.6	7	2
Subtotal: Non-milk fraction of diet	-------	-------	-------	1.9	145	77
Milks:						
Formula	37	0.95	0.39	0.41	14	35
Evaporated	137	1.56	0.39	0.25	53	214
Subtotal: Milk fraction of diet	-------	-------	-------	0.27	67	249
Total: Combined milk and non-milk fractions	-------	-------	-------	0.65	212	326

Strontium-90 Concentration In Bread In New York City

Health and Safety Laboratory, U.S. Atomic Energy Commission

The following table presents data on strontium-90 concentrations in bread purchased in New York City during October 1960 through January 1961. One loaf of each type was purchased daily from a local grocer and the loaves were composited on a monthly basis. Five brands were represented in each month's sample. Daily sampling of bread for monthly compositing was discontinued after January 1961. Instead, bread samples will be obtained at the same time the quarterly sampling is made in New York City for the 19 food categories listed in Tri-City Diet Study.

Previous results were reported in *Radiological Health Data,* Volume I, Numbers 7 and 9, and Volume II, Numbers 4 and 6.

TABLE 1.—STRONTIUM-90 AND CALCIUM IN BREAD PURCHASED IN NEW YORK CITY, OCTOBER 1960–JANUARY 1961[1]

Month	Calcium		Strontium-9					
	gm/kg of original material		μμc/kg of original material		μμc/gm Ca		μμc daily intake [3]	
	Whole-wheat	White	Whole-wheat	White	Whole-wheat	White	Whole-wheat	White
October 1960	0.69	0.63	17	6	24	9	0.06	0.28
November 1960	0.39[2]	0.58	15	8	37	14	0.05	0.37
December 1960	0.81	0.85	21	8	26	9	0.08	0.37
January 1961	0.77	0.76	18	5	24	7	0.06	0.23
Average 1959	-------	-------	-------	-------	46	12	-------	-------
Average 1960	-------	-------	-------	-------	28	12	-------	-------

[1] Data taken from *Quarterly Summary Report*, HASL-113, dated July 1, 1961.

[2] Questionable calcium value.

[3] Values calculated by staff of Data Collation and Analysis Unit, Division of Radiological Health, Public Health Service, from U. S. Department of Agriculture data on average daily per capita consumption of 3.6 gm/day of whole-wheat bread and 46.2 gm/day of white bread (see *Radiological Health Data*, Volume I, Number 5).

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SECTION III. — MILK

Milk Monitoring Program

Division of Radiological Health, Public Health Service

There are two Public Health Service Milk Monitoring Programs. The original network consisted of five milkshed sampling stations. It was later expanded to twelve stations, nine of which are still active. Raw milk is spot sampled at these stations. During 1960, a processed milk sampling program of 60 stations was established. Since the sampling procedures for the raw milk sampling stations and the processed milk area sampling stations are different, they are described and reported separately. The Public Health Service Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, continues to conduct the analyses for the original network stations; the Public Health Service Southeastern Radiological Health Laboratory at Montgomery, Alabama, and the Southwestern Radiological Health Laboratory at Las Vegas, Nevada, provide analytical services for the new program.

The objectives of the two sampling programs are not the same. The original network was established to develop sampling and radiochemical analytical proficiencies under conditions which would remain similar over a period of time in regard to the source of milk. During the operation of this program it became apparent that a broader sampling program more directly related to the milk consumed by the population was necessary. The Public Health Service, Department of Health, Education, and Welfare, acted to provide facilities for this change. This resulted in the transition from the program of sampling raw milk, collected from milksheds of limited size, to a sampling program designed to be representative of the processed milk consumed in a given municipality.

In some instances, the newly designated stations are the same as those which were reported originally. The establishment of the new processed milk area sampling stations does not preclude the need for further raw milk sampling from the selected milkshed serving the same city. It is important that both networks be in operation for a sufficient period of time to provide an overlap for the purpose of a comparative study.

Because of the different sources of these samples, changes in the method of collecting samples, and the utilization of different laboratory techniques, differences were anticipated in the amounts of radioactivity in the milk under the two programs. For this reason, an investigation to determine the comparability of the two programs was begun in January 1961. This investigation covers many factors including laboratory methodology and collection methods. Until this study has been completed, and additional experience has been gained under the new program, no valid interpretation can be made of any differences of radioactivity in milk samples collected under the two systems.

Publication of the data from each program will normally follow about four months after sample collection because of the time required for shipment, processing, decay product build-up, compilation of the data, and clearance and publication procedures.

Raw Milk Sampling Stations

The initial purpose of establishing this network was in keeping with the normal and continuing program of the Public Health Service to determine trends in our changing environment with respect to measuring the amounts of radioactivity in water, air, milk, and other foods. Milk was the food chosen for initial testing because it is among the most important components of the diet and is available at all seasons of the year and in all climates. A primary objective of the project was to develop effective collection systems and radiochemical analysis procedures which would make them more suitable for larger scale programs.

The criteria on which the selection of the original sampling stations was based appeared in the discussion sections of all Volume I issues of *Radiological Health Data.*

One-gallon raw milk samples are collected from a dairy company once each month and forwarded by air parcel post to the Robert A. Taft Sanitary Engineering Center for radionuclide analyses. These samples represent between 2,000- and 90,000-gallon lots. The concentration of iodine-131, barium-140, and cesium-137 are currently being measured by gamma scintillation spectroscopy. Total radiostrontium and strontium-90 are determined following radiochemical separations. The amount of strontium-90 is calculated by measuring the buildup of the strontium-90 daughter decay product, yttrium-90, over a two-week period. Measurements are made in a low background anticoincidence beta counter. The total radioactive strontium is counted in a shielded internal proportional counter. The difference between the total strontium and strontium-90 is reported as strontium-89. Stable calcium is also determined.

The April through September 1960 issues of *Radiological Health Data* list references for technical descriptions of analytical procedures.

Table 1 presents first quarter averages for 1961 and the April 1961 data for the raw milk sampling stations.

Processed Milk Area Sampling Stations

The processed milk surveillance program will provide additional information on levels of radioactivity in milk consumed by the public. The new stations have been established in cooperation with State and local health and milk sanitation agencies. Each city has been selected to provide adequate coverage with respect to production areas and the consuming population. The emphases of this expanded sampling and radioassay program are:

1. to measure the levels of radioactivity of the milk consumed by the public in various regions of the country by obtaining samples of pasteurized and homogenized milk at the processing plant, and
2. to provide one sampling point within

TABLE 1.—RADIOACTIVITY IN MILK—RAW MILK SAMPLING STATIONS, FIRST QUARTER AND APRIL 1961

[Radioactivity concentrations in $\mu\mu c$/liter]

Area	Calcium (gm/liter)		Strontium-90		Cesium-137		Area	Calcium (gm/liter)		Strontium-90		Cesium-137	
	First quarter	April	First quarter	April	First quarter	April		First quarter	April	First quarter	April	First quarter	April
Atlanta, Ga	1.18	1.19	13	11	25	25	Salt Lake City, Utah	1.19	1.18	4	3	10	<5
Austin, Tex	1.16	1.17	7	3	15	10	Spokane, Wash	1.22	1.14	7	7	15	15
Chicago, Ill	1.17	1.14	6	9	20	15	St. Louis, Mo	1.26	1.18	13	20	25	20
Cincinnati, Ohio	1.21	1.17	8	10	15	15							
New York, N.Y	1.11	1.13	9	7	20	20							
Sacramento, Calif	1.19	1.16	5	2	10	5	Average	1.19	1.16	8	8	15	14

Note: I^{131}, Sr^{89} and Ba^{140} are below minimum detectable limits for samples collected in April. These limits are 10 $\mu\mu c$/liter for I^{131} and Ba^{140} and 5 $\mu\mu c$/liter for Sr^{89}.

each State with additional points when indicated by widely varying conditions of the milk supply or the need to provide coverage of large population groups.

The new network was designed to sample processed milk rather than the raw product. The sampling procedure was developed to provide a sample from one day's sales per month in a community which would be as representative of the total supply as can be achieved under practical conditions. Each sample is a composite of those plants supplying not less than 90 percent of a city's milk supply. The contribution from each plant to the total sample is approximately proportional to the volume of milk sold.

The samples from the new stations are collected with the assistance of the various State and local health and milk sanitation agencies and are shipped for analyses to either the Southwestern or Southeastern Radiological Health Laboratory. The Southeastern Radiological Health Laboratory processes samples from the 30 states generally east of the Mississippi, and the Southwestern Radiological Health Laboratory processes samples from the western states. Figure 1 shows the locations of these stations.

At the present time, radioassays for Sr^{90}, Cs^{137}, Sr^{89}, Ba^{140} and I^{131} are being performed. The latter three radionuclides are not presently found in milk by the current methods of detection. The lower level of detection for Sr^{89} is 5 μμc/liter, and for Ba^{140} and I^{131}, 10 μμc/liter. Other radionuclides of concern to public health agencies will be included for assay as necessary for a more complete monitoring of the milk supply.

Table 2 presents first quarter averages for 1961 and the April 1961 data for the processed milk sampling stations.

FIGURE 1.—PROCESSED MILK AREA SAMPLING STATIONS

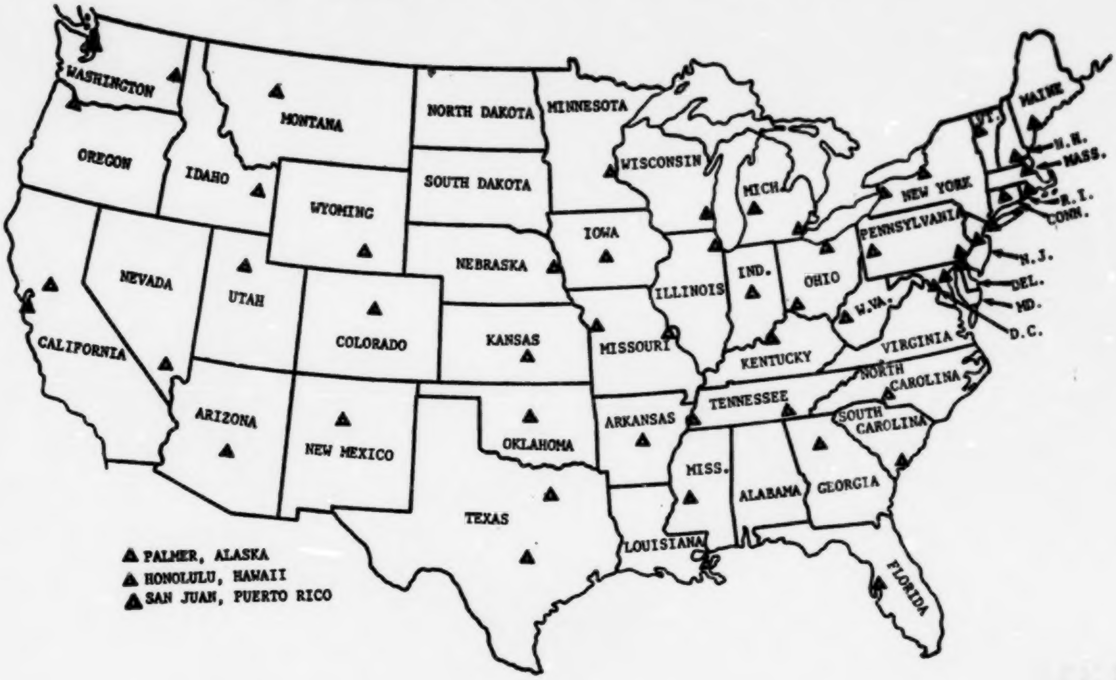

TABLE 2.—RADIOACTIVITY IN MILK—PROCESSED MILK AREA SAMPLING STATIONS, FIRST QUARTER AND APRIL 1961

[Radioactivity concentrations in μμc/liter]

Area	Calcium (gm/liter)		Strontium-90		Cesium-137	
	First quarter	April	First quarter	April	First quarter	April
Albuquerque, N. Mex	1.05	1.02	5	3	<5	<5
Atlanta, Ga	1.21	1.24	7	8	5	10
Austin, Tex	1.26	1.23	2	3	<5	<5
Baltimore, Md	1.28	1.24	6	7	5	15
Boston, Mass	1.27	1.24	8	9	10	20
Buffalo, N.Y	[a] 1.18	1.23	[a] 6	7	[a] <5	5
Burlington, Vt	1.23	1.24	9	7	5	10
Charleston, S.C	1.35	1.24	8	12	5	15
Charleston, W. Va	1.21	1.24	5	6	<5	<5
Charlotte, N.C	1.28	1.28	9	14	<5	<5
Chattanooga, Tenn	1.33	1.26	8	14	<5	10
Chicago, Ill	[a] 1.16	1.18	[a] 6	9	[a] <5	<5
Cincinnati, Ohio	1.24	1.26	7	8	<5	10
Cleveland, Ohio	1.21	1.20	6	9	<5	<5
Dallas, Tex	1.29	1.22	5	10	<5	10
Denver, Colo	1.03	.98	6	5	5	<5
Des Moines, Iowa	1.07	1.01	7	8	<5	<5
Detroit, Mich	1.19	1.16	6	7	<5	<5
Grand Rapids, Mich	1.24	1.25	7	5	<5	<5
Hartford, Conn	1.19	1.22	7	9	10	20
Helena, Mont	1.04	.98	4	6	5	<5
Honolulu, Hawaii	1.05	.92	4	5	<5	5
Idaho Falls, Idaho	1.05	.99	5	4	<5	<5
Indianapolis, Ind	1.26	1.28	7	7	<5	<5
Jackson, Miss	1.37	1.38	10	16	5	15
Kansas City, Mo	1.05	(b)	7	(b)	<5	(b)
Laramie, Wyo	1.06	.96	5	5	<5	5
Las Vegas, Nev	1.03	.96	3	3	<5	<5
Little Rock, Ark	1.27	1.24	13	20	5	25
Louisville, Ky	1.21	1.20	7	10	<5	10
Manchester, N.H	1.21	1.20	8	11	15	35
Memphis, Tenn	1.30	1.32	8	14	<5	<5
Milwaukee, Wis	1.23	1.27	5	6	<5	20
Minneapolis, Minn	1.00	1.01	7	9	<5	5
New Orleans, La	1.31	1.30	8	10	10	25
New York, N.Y	[a] 1.18	1.19	[a] 7	8	[a] 5	20
Norfolk, Va	[a] 1.20	1.31	[a] 7	8	[a] <5	15
Oklahoma City, Okla	1.29	1.25	5	8	<5	<5
Omaha, Nebr	1.05	1.12	7	3	5	<5
Palmer, Alaska	1.08	1.06	6	10	<5	<5
Philadelphia, Pa	1.27	1.24	7	9	<5	15
Phoenix, Ariz	1.09	.93	2	5	<5	<5
Pittsburgh, Pa	1.24	1.36	9	12	<5	<5
Portland, Me	[a] 1.20	1.25	[a] 10	12	[a] 10	35
Portland, Oreg	1.11	1.07	8	10	10	20
Providence, R.I	1.26	1.06	9	7	10	25
Sacramento, Calif	1.12	1.06	3	6	<5	<5
Salt Lake City, Utah	1.05	1.03	4	4	5	<5
San Francisco, Calif	1.05	.95	3	7	<5	5
San Juan, P.R	1.15	1.20	3	4	<5	<5
Seattle, Wash	1.09	.94	7	8	10	15
Spokane, Wash	1.12	1.06	7	6	5	5
St. Louis, Mo	1.01	1.06	7	8	10	15
Syracuse, N.Y	1.22	1.12	6	7	<5	15
Tampa, Fla	1.26	1.28	5	8	35	90
Trenton, N.J	1.24	1.21	7	8	<5	5
Washington, D.C	1.23	1.20	6	6	<5	<5
Wichita, Kans	1.05	1.01	5	6	<5	5
Wilmington, Del	1.22	1.20	7	7	<5	15
Average	1.18	1.16	6	8	<5	10

[a] Average based on two months.
[b] No sample collected.

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SECTION IV. — WATER

National Water Quality Network

Division of Water Supply and Pollution Control, Public Health Service

The National Water Quality Network operates under the provision of Section 4(c) of the Federal Water Pollution Control Act, which states ". . . The Secretary shall . . . . collect and disseminate basic data . . . (relating) to water pollution and the prevention and control thereof."

This Network, operated in cooperation with State and local agencies, and industrial organizations commenced operations in October 1957. At present, there are 86 sampling stations located on major waterways used for public water supply, propagation of fish and wildlife, recreational purposes, and for agricultural, industrial, and other uses. Some of these stations are interstate, coastal, and International Boundary waters, and waters on which activities of the Federal Government may have an impact. Ultimately, a total of approximately 300 stations will be in operation. Radioactivity is not yet being reported for a few of the more recently established stations.

Samples of water are examined for chemical, physical, and biological quality insofar as these relate to pollution. Samples for some determinations are taken weekly, others monthly, and for some, continuous composite samples of 10 to 15 days are obtained.

Gross alpha and beta measurements are made on both suspended and dissolved solids in raw surface water samples. The levels of radioactivity associated with dissolved solids provide a rough measure of the levels which may be found in a treated water, where such water treatment removes substantially all of the suspended matter. Naturally-occurring radioactive substances in the environment are the source of essentially all of the alpha activity. The contamination of the environment from man-made sources is the major contributor to the beta activity. It should be noted that with the cessation of weapons testing, the beta activity in most raw waters is generally approaching a level attributable solely to natural sources. Natural beta activity can be two or three times the natural alpha activity based on the presence of the same nuclides. Some exceptions to this are seen, notably in the data for the Columbia, Tennessee and Animas Rivers.

For the first two years of the network operations, beta determinations were made on weekly samples. Alpha determinations were reported generally on composites of more than one weekly sample.

Beginning January 1, 1960 the frequency of beta determinations has varied depending on the status of each particular station. For the first operating year of each new station, analyses have been conducted weekly. Weekly analyses are continued indefinitely from all stations which may be affected by waste discharges from nuclear installations. Semimonthly determinations (on composites of 2 or 3 weekly samples) are conducted for stations which still show some beta activity above background. Monthly determinations (on composites of all samples received from a station during the month) are conducted on samples from streams where beta activity is at background levels.

Beginning January 1, 1960, the frequency of alpha determinations has also been changed. For the first operating year of each new station, analyses have been done weekly. Semimonthly determinations are conducted at some collecting points on the Animas and Colorado Rivers by compositing 2 or 3 weekly samples. The remainder of the stations have determinations made quarterly on composites of all samples taken during that quarter.

Schedules of determinations are so arranged that each river basin has one gross alpha determination each month. All data reported in table 1 represent the average of all information available for the month indicated. Reported strontium-90 data are the results of determinations on composite samples for a three-month period ending in the month shown.

Additional information and data may be obtained from the following sources:

National Water Quality Network Annual Compilation of Data, PHS Publication. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Price $1.50.

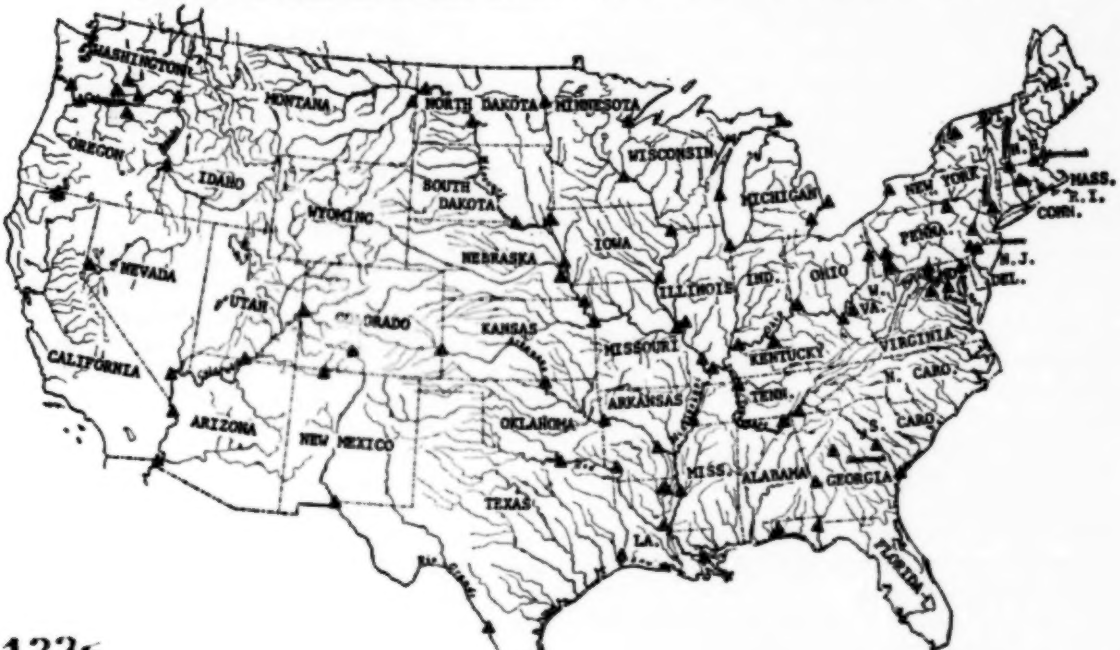
"Report on National Water Quality Control Network," submitted by Dr. F. J. Weber, Chief, Division of Radiological Health, PHS, at the Joint Committee on Atomic Energy Hearings on Fallout from Nuclear Weapons Tests, Vol. 1, May 1959, pages 167-169.

Setter, L. R., Regnier, J. E., and Diephaus, A., "Radioactivity of Surface Waters in the United States," Jour. AWWA *51*, 1377 (1959).

Straub, C. P., Setter, L. R., Goldin, S., and Hallbach, P. F., "Strontium-90 in Surface Waters," Jour. AWWA *52*, 756 (1960).

Setter, L. R., and Baker, S. L., "Radioactivity of Surface Waters in the United States," *Radiological Health Data*, Volume I, No. 7 (1960).

FIGURE 1.—NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS



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As of June 1, 1961

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS
[Concentrations in μμc/liter]

Station	Quarter ending December 31, 1960	March 1961					
	Strontium-90	Beta activity			Alpha activity		
		Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River: Pittsburgh, Pa.	(a)	2	<1	2	<1	0	<1
Animas River: Cedar Hill, N. Mex.	-----	598	19	617	64	16	80
Apalachicola River: Chattahoochie, Fla.	-----	0	<1	<1	1	0	1
Arkansas River:							
Coolidge, Kans.	-----	0	0	0	0	49	49
Ponca City, Okla.	-----	38	0	38	1	5	6
Pendleton Ferry, Ark.	(b)	0	0	1	1	0	1
Chattahoochie River:							
Atlanta, Ga.	0.3	0	0	0	1	0	1
Columbus, Ga.	-----	0	1	1	1	0	1
Colorado River:							
Loma, Colo.	-----	2	0	2	10	14	24
Page, Ariz.	0.4	28	3	31	25	14	39
Hoover Dam, Ariz.-Nev.	-----	0	12	12	0	6	6
Parker Dam, Ariz.-Calif.	1.2	0	20	20	0	5	5
Yuma, Ariz.	-----	0	22	22	1	13	14
Columbia River:							
Wenatchee, Wash.	-----	<1	<1	2	<1	0	<1
Pasco, Wash.	-----	103	526	629	0	0	0
Bonneville Dam, Oreg.	0.5	66	176	242	-----	-----	-----
Clatskanie, Oreg.	-----	19	43	62	-----	-----	-----
Delaware River:							
Martins Creek, Pa.	-----	0	2	2	0	0	0
Philadelphia, Pa.	-----	0	0	0	0	1	1
Escambia River: Century, Fla.	(b)	0	0	0	1	0	1
Great Lakes:							
Buffalo, N.Y.	-----	0	0	0	0	0	0
Port Huron, Mich.	-----	0	0	0	0	0	0
Gary, Ind.	-----	0	0	0	0	0	0
Duluth, Minn.	-----	0	0	0	0	0	0
Milwaukee, Wisc.	0.2	0	0	0	<1	<1	<1
Sault Ste. Marie, Mich.	-----	0	0	0	0	0	0
Hudson River: Poughkeepsie, N.Y.	0.4	2	0	2	2	0	2
Illinois River: Peoria, Illinois	0.5	1	6	7	2	1	3
Kanawha River: Winfield Dam, W. Va.	-----	<1	0	<1	0	0	0
Klamath River: Copco, Oreg.	-----	0	2	2	0	<1	<1
Little Miami River: Cincinnati, Ohio	-----	1	0	1	2	0	2
Mississippi River:							
Minneapolis, Minn.	-----	0	0	0	0	1	1
Burlington, Iowa	-----	0	6	6	5	1	6
E. St. Louis, Ill.	-----	87	6	93	28	0	28
Cape Girardeau, Mo.	-----	76	0	76	30	0	30
West Memphis, Ark.	1.0	10	3	13	7	0	7
Delta, La.	-----	9	5	14	4	1	5
New Orleans, La.	-----	5	1	6	2	0	2
Missouri River:							
Williston, N.D.	-----	1	0	1	2	3	5
Bismarck, N.D.	-----	0	3	3	0	3	3
Yankton, S.D.	-----	0	1	1	0	4	4
Omaha, Nebr.	-----	122	3	125	61	2	63
St. Joseph, Mo.	0.5	149	0	149	96	2	98
Kansas City, Kans.	-----	481	0	481	86	1	87
St. Louis, Mo.	-----	4	10	14	18	2	20
Ohio River:							
East Liverpool, O.	-----	0	2	2	1	0	1
Huntington, W. Va.	-----	1	0	1	3	0	3
Wheeling, W. Va.	0.6	-----	-----	-----	-----	-----	-----
Cincinnati, Ohio	-----	4	1	5	2	<1	2
Evansville, Ind.	0.8	0	0	0	0	0	0
Cairo, Ill.	-----	12	2	14	2	0	2
Potomac River:							
Hagerstown, Md.	-----	4	0	4	1	0	1
Great Falls, Md.	-----	4	4	8	1	0	1
Red River, North: Grand Forks, N.D.	-----	0	5	5	0	2	2
Red River, South:							
Index, Ark.	-----	3	0	3	2	1	3
Alexandria, La.	-----	11	2	13	5	0	5
Denison, Tex.	0.7	0	0	0	0	0	0
Rio Grande River:							
Alamosa, Colo.	-----	0	0	0	0	2	2
El Paso, Tex.	-----	0	0	0	8	5	13
Laredo, Tex.	-----	0	0	0	0	2	2
Brownsville, Tex.	-----	<1	0	<1	0	2	2
Sabine River: Ruliff, Tex.	-----	<1	2	2	<1	0	<1
St. Lawrence River: Massena, N.Y.	0.6	<1	<1	<1	0	0	0
Schuylkill River: Philadelphia, Pa.	(b)	0	2	2	0	0	0
Savannah River:							
Port Wentworth, Ga.	0.5	<1	26	26	1	0	1
North Augusta, S.C.	-----	0	0	0	0	0	0
Snake River: Wawawai, Wash.	-----	0	0	0	0	1	1
Susquehanna River:							
Sayre, Pa.	-----	0	2	2	<1	<1	1
Conowingo, Md.	0.4	0	0	0	2	0	2
Tennessee River:							
Chattanooga, Tenn.	0.9	0	52	52	-----	-----	-----
Bridgeport, Ala.	-----	<1	87	87	1	0	1
Yellowstone River: Sidney, Mont.	-----	15	0	15	8	7	15

[a] Dash denotes no sample received or no determinations made.
[b] Insufficient sample for analysis.

Strontium-90 In Tap Water

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Atomic Energy Commission's Health and Safety Laboratory performs analyses for strontium-90 concentrations in tap water for Richmond, California, and New York City on a monthly basis. Previous data were presented in *Radiological Health Data*, Volume I, Numbers 1, 5, and 9, and Volume II, Number 4.

TABLE 1.—STRONTIUM-90 IN TAP WATER[1]
FOURTH QUARTER 1960

Location	Month	Activity ($\mu\mu c$/liter)
Richmond, California (40 liters per sample)	October November December	0.26 0.28 0.26
	Average 1959 Average 1960	0.29 0.26
New York City (100-200 liters per sample)	October November December	0.33 0.34 0.34
	Average 1959 Average 1960	0.40 0.47

[1] Data from *Quarterly Summary Report*, HASL-113, dated July 1, 1961.

Study Of Radium-226 Content Of Midwest Water Supplies [1]

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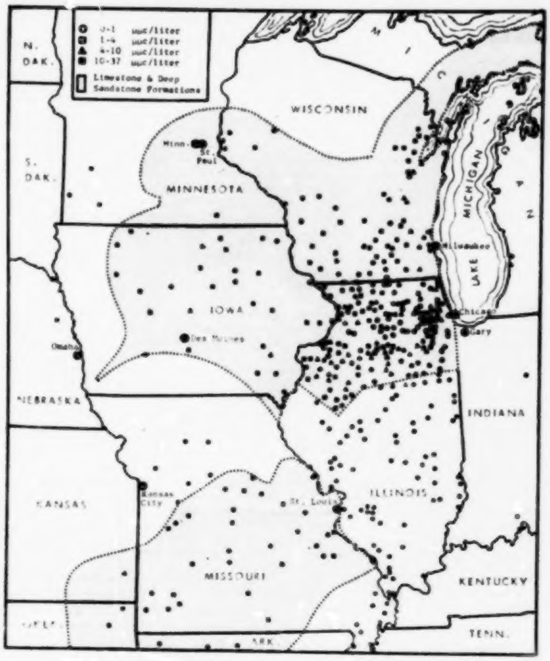
In previous work, water from certain midwest municipal water systems was found to contain less than 0.03 to 37 micromicrograms per liter ($\mu\mu g$ liter) of radium-226 (Ra^{226}), concentrations which correlate well with source type and method of softening. Water derived from surface sources such as rivers or lakes, wells penetrating unconsolidated sand or gravel deposits of glacial origin, limestone formations of Silurian or Devonian age were, with rare exception, found to contain less than 1 $\mu\mu g$ Ra^{226}/liter. In contrast, wells penetrating deep sandstone formations of Ordovician, Cambrian or Pre-Cambrian ages had Ra^{226} contents from 1 to 37 $\mu\mu g$/liter (1, 2).

These deep sandstone formations are known to exist over an area not less than 300,000 square miles in extent (3). In a portion of this area the quality and quantity of the water is suitable for drinking and other municipal purposes. The broken line in figure 1 outlines the two largest areas in the United States obtaining water from consolidated rock (limestone and deep sandstone) formations (4).

FIGURE 1.—RADIUM-226 CONTENT OF MUNICIPAL DRINKING WATER



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[1] Reported in *Semiannual Report*, January through June 1960, Radiological Physics Division, Argonne, National Laboratory.

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This area is seen to cover much of Wisconsin, Minnesota, Iowa, Illinois, and Missouri.

As part of an extensive study of the Ra^{226} content of municipal drinking waters in these and adjoining regions, the study of Illinois is complete, with at least one water sample collected and analyzed from 163 of the 165 communities comprising more than 99 percent of the total population suspected of consuming water with high radium content.

The distribution of the samples and the range of Ra^{226} content is shown in figure 1. On this map, the symbols denote the ranges of Ra^{226} content in the drinking water of 0-1, 1-4, 4-10, and 10-37 μμg/liter.

With two exceptions, concentrations of Ra^{226} in excess of 4 μμg/liter have been found thus far only in Illinois, Iowa, and Wisconsin. Cities having Ra^{226} content greater than 10 μμg/liter in their water supply have been found, thus far, only in Illinois, Iowa, and Missouri, and their total population is about 37,000 (1950 census). The total population, identified to date consuming water in excess of 1 μμg/liter is 1,000,000. Of these, about one-half or 480,000 consume water having a Ra^{226} content in excess of 4 μμg/liter, a level leading to a whole-body radium content presently estimated to be at least 5 times that obtainable from normal food alone. The data are summarized in table 1.

TABLE 1.—SUMMARY OF POPULATIONS CONSUMING WATER IN VARIOUS RANGES OF Ra^{226} CONTENT

	Range (μμg/liter)	Number of cities	Total population (1950 census)
Illinois	0.0-0.9	131	1,035,414
	1.0-3.9	56	248,248
	4.0-9.9	41	320,508
	10-37	19	30,261
Iowa	0.0-0.9	16	156,914
	1.0-3.9	10	43,855
	4.0-9.9	4	38,716
	10-11.7	1	5,843
Missouri	0.0-0.9	32	155,830
	1.0-3.9	14	81,314
	4.0-9.9	0	0
	10-10.4	1	1,218
Wisconsin	0.0-0.9	28	196,722
	1.0-3.9	25	221,175
	4.0-9.9	8	81,740
	≥10	0	0
Total	0.0-0.9	207	1,544,880
	1.0-3.9	105	595,108
	4.0-9.9	53	440,964
	≥10	21	37,322
Grand total		386	2,617,418

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(1) Lucas, H. F., Jr., and F. H. Ilcewicz. J. Am. Water Works Assoc. *50* 1523-1532 (1958).

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(3) Meinzer, O. E. Occurrence of Ground Water in the United States. USGS, Water Supply Paper No. 489, Govt. Printing Office (1923).

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Radium-228 In Midwest Well Waters [1]

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Argonne National Laboratory, U.S. Atomic Energy Commission

Concurrent with the program to determine the radium-226 (Ra^{226}) concentration levels in well waters from the midwestern states of Illinois, Wisconsin, Missouri, and Iowa, measurements of the radium-228 (Ra^{228}), (Mesothorium I) levels are also being made (1-4). Waters were selected having Ra^{226} levels equal to or greater than 4μμc/liter, and these, without exception were obtained from wells penetrating deep sandstone formations. Although no definite pattern can be established, it appears that in Illinois certain areas yield reasonably constant ratios of Ra^{228}/Ra^{226}, but that throughout the state this ratio varies from 0.04 to 2.4 and is dependent upon the aquifer or aquifers from which the water is drawn (5). Previous work on samples from other than deep sandstone wells has shown that the Ra^{226} and Ra^{228} concentrations are low or nearly equal, i.e., the Ra^{228}/Ra^{226} ratio approaches unity (3).

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[1] Reported in *Semiannual Report*, January through June, 1960, Radiological Physics Division, Argonne National Laboratory.

The data for some Illinois deep sandstone wells are presented in table 1 and are tabulated by ascending values of the Ra^{228}/Ra^{226} ratio. The table also classifies the wells as to the type of aquifer from which the principal supply is believed to be drawn. The information regarding the wells was taken primarily from Bulletin No. 40 of the Illinois State Water Survey and from the sampling record sheet completed by the local water department (6).

It is evident from table 1 that waters derived chiefly from St. Peters sandstone (Ordovician system) are generally low in Ra^{228} but high in Ra^{226}, whereas waters derived from the underlying Galesville sandstone formation (Cambrian system) have more nearly equal concentrations of the two isotopes. In each case, however, there are exceptions to these general statements, and for these no good explanation is available other than lack of information describing the well or local geological conditions.

To illustrate the latter point, the towns of Lostant, Toluca, Wenona, and Minonk may be cited. These four towns are located in an area which has a north-south dimension of about 15 miles and an east-west dimension of about 6 miles in a region where a geological fault is known to exist (7). The information available indicates that the wells in these towns penetrate the St. Peters sandstone, but the average Ra^{228}/Ra^{226} ratio is 0.81 for the group in contrast with an average of 0.11 for the first 15 towns listed in table 1.

TABLE 1.—RADIUM CONTENT OF WATER FROM SOME DEEP SANDSTONE WELLS IN ILLINOIS

Town	St. Peter's Sandstone	Galesville Sandstone	Mt. Simon Sandstone	Limestone	Other	Radium-228 (μμc/liter)[a]	Radium-226 (μμc/liter)[b]	Ratio:— Ra^{228}/Ra^{226}
Toulon	[c]X					1.3	36.0	0.04
Ipava	X					1.9	25.0	0.07
Farmington	X					0.6	7.5	0.08
Depue #1	X					0.7	9.2	0.08
Viola	X					0.6	8.1	0.08
Glasford	X			X		1.1	11.6	0.09
Depue #2-[illegible]	X					1.0	9.7	0.10
Depue #2	X					1.1	9.6	0.11
Alpha	X			X		0.7	6.4	0.11
Woodhull	X			X		0.5	4.2	0.12
Shannon	X					2.1	17.0	0.12
Odell	X					1.5	11.2	0.13
Biggsville	X			X		2.4	16.0	0.15
Bushnell	X					3.4	18.0	0.19
Elmwood	X					1.8	8.2	0.22
Sterling	X	X				0.9	3.9	0.23
Galesburg	X	X				2.0	8.1	0.25
Monmouth	X	X				2.0	6.6	0.30
Chenoa	X			X	(d)	2.2	7.3	0.30
Fulton		X	X			1.5	4.8	0.31
Silvis				X	(d)	1.5	4.6	0.33
Ladd	X				X	2.6	7.4	0.35
Standard	X					2.4	6.6	0.36
Byron	X	X	X			1.8	4.7	0.38
Freeport	X				X	1.4	3.5	0.40
Lake Bluff	X (?)	X	X	X		2.2	5.8	0.42
Lombard	X	X				3.6	8.6	0.42
Wilmington	X	X		X		5.3	10.2	0.52
Elmhurst	X	X				2.7	5.1	0.53
Ottawa		X				3.8	6.4	0.59
De Kalb #6	X	X				2.9	4.9	0.59
Kewanee	X	X				4.9	8.1	0.60
Rockford		X	X		X	2.2	3.5	0.63
De Kalb #7	X	X				2.0	3.1	0.64
Lostant	X					6.5	9.9	0.66
Savanna			X			2.0	3.0	0.67
Plainfield	X	X				5.4	8.0	0.68
Lockport	X	X				7.9	11.2	0.70
Toluca	X					5.3	7.3	0.73
Villa Park	X	X	X	X		3.3	4.2	0.78
Morris #4		X				6.6	8.0	0.82
Oregon		X	X			2.7	3.1	0.87
Geneva		X	X			5.8	6.4	0.91
Braidwood	X	X		X		5.8	6.4	0.91
Minonk #2	X			X		7.1	7.8	0.91
Wenona	X					9.1	9.3	0.98
Argonne deep well	X	X	X	X		5.2	5.0	1.04
Joliet		X				7.0	6.7	1.04
Aurora	X (?)	X	X			8.0	6.8	1.18
Kinsman	X			X	X	5.4	4.4	1.23
Batavia		X	X			8.0	5.6	1.43
Morris	X					5.6	2.3	2.43

[a] Estimated error in Ra^{228} values is ±10%.

[b] Statistical counting error equal to or less than 3%.

[c] "X" denotes formation from which sample was drawn.

[d] New Richmond sandstone.

TABLE 2.—RADIUM CONTENT OF WATER FROM SOME DEEP SANDSTONE WELLS IN WISCONSIN AND MISSOURI

Town	Radium-228[a] (μμc/liter)	Radium-226[b] (μμc/liter)	Ratio Ra^{228}/Ra^{226}
Wisconsin			
Hartford	1.5	6.2	0.24
Fond du Lac	2.7	6.6	0.41
Burlington	2.0	4.2	0.47
Peshtigo	2.1	3.6	0.58
Kaukauna	2.7	4.0	0.67
Oconto	2.4	3.6	0.67
Menomonee Falls	5.0	4.7	1.06
Waukesha	8.8	4.2	2.09
Missouri			
Clinton #2	1.8	10.4	0.17
Clinton #1	1.9	9.0	0.21
Concordia	4.4	10.5	0.42

[a] Estimated error ±10%.
[b] Statistical counting error equal to or less than 3%.

Some deep sandstone wells in Wisconsin and Missouri have also been analyzed for both Ra^{228} and Ra^{226}. Table 2 is a summary of the data obtained thus far.

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(3) Krause, D. P., Radiological Physics Division *Semiannual Report*, ANL-6049 (October 1959) pp. 51-52.

(4) Lucas, H. F., Radiological Physics Division *Semiannual Report*, ANL 6199 (August 1960), p. 82.

(5) Lucas, H. F., and Krause, D. P. Radiology *74* 114 (1960).

(6) Hanson, Ross, *Public Ground-Water Supplies in Illinois*, Illinois State Water Survey Bulletin No. 40 (1950).

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SECTION V. — OTHER DATA

External Gamma Activity

Radiation Surveillance Network, Public Health Service

Portable survey instruments are available at stations of the Radiation Surveillance Network for recording levels of external gamma radiation. Measurements are made daily approximately three feet above the ground. These readings are not precise, but are sufficiently accurate to illustrate any significant variations above background. The differences among the values shown in the following table are within the variance anticipated due to differences in normal background and in instrument response characteristics.

TABLE 1.—EXTERNAL GAMMA ACTIVITY, APRIL 1961

Station location	Average (mr/hr)	Station location	Average (mr/hr)	Station location	Average (mr/hr)
Anchorage, Alaska	0.01	Indianapolis, Ind	0.01	Oklahoma City, Okla	0.03
Fairbanks, Alaska	(a)	Iowa City, Iowa	0.02	Ponca City, Okla	0.04
Juneau, Alaska	0.01	Topeka, Kans	0.02	Portland, Oreg	0.02
Phoenix, Ariz	0.01	New Orleans, La	0.01	Harrisburg, Pa	0.01
Little Rock, Ark	0.02	Baltimore, Md	0.02	Providence, R.I	0.02
Berkeley, Calif	0.01	Lawrence, Mass	0.02	Columbia, S.C	0.02
Los Angeles, Calif	(a)	Lansing, Mich	0.02	Pierre, S. Dak	0.02
Denver, Colo	0.02	Minneapolis, Minn	0.01	Austin, Tex	0.01
Hartford, Conn	0.01	Pascagoula, Miss	(a)	El Paso, Tex	0.02
District of Columbia	0.02	Jefferson City, Mo	0.01	Salt Lake City, Utah	0.02
Jacksonville, Fla	0.01	Helena, Mont	0.07	Richmond, Va	0.01
Atlanta, Ga	(a)	Trenton, N.J	0.02	Seattle, Wash	0.02
Honolulu, Hawaii	0.03	Santa Fe, N. Mex	(a)	Cheyenne, Wyo	0.02
Boise, Idaho	0.01	Albany, N.Y	0.02	Madison, Wis	0.01
Springfield, Ill	0.01	Gastonia, N.C	0.02		

[a] No data received.

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Survey Of Radioactivity In Animal Fodder

Food and Drug Administration

A part of the continuing surveillance of radioactivity in foods by the Food and Drug Administration is concerned with the levels of strontium-90 in animal fodders. *Radiological Health Data,* Volume I, Number 9 presented the strontium-90 analysis of animal fodder collected in 1959. The following table gives the results of analysis of feeds collected in 1960 by representatives of Food and Drug Administration Districts.

TABLE 1.—STRONTIUM-90 CONTENT OF ANIMAL FODDERS, 1960

[Concentrations in $\mu\mu c$/kg original material]

Product	Harvest date	Area		Strontium-90
		County	State	
Alfalfa hay	August	Hamilton	Ohio	157
Timothy & clover hay	August	Hamilton	Ohio	426
Lespedeza hay	August 15	Forsyth	North Carolina	248
Alfalfa hay	August 15	Forsyth	North Carolina	297
Alfalfa hay	March 30, May 20	Sumter	Georgia	425
Lespedeza hay	September 15	Henry	Georgia	446
Peanut hay	August	Irwin	Georgia	578
Peanut hay	August 21	Tift	Georgia	798
Peanut hay	August 28	Ben Hill	Georgia	721
Peanut hay	September 5	Worth	Georgia	931
Alfalfa hay	August 18	Conejos	Colorado	64
Dry sugar beet pulp	October	Buffalo & Kearney	Nebraska	127

Global Integrals Of Strontium-90 Fallout[1]

Kosta Telegadas
U.S. Weather Bureau

Monthly collections of fallout have been made for a period of several years using both steel pots and ion-exchange collectors (1). The samples are analyzed for strontium-90 (Sr^{90}) and several other radioisotopes.

The geographical distribution of fallout supports the north-south distribution noted by previous articles on soil (2) and limited pot data (2). The difference between Northern and Southern Hemisphere shows the same seasonal trend also suggested in earlier data, i.e., a maximum excess of Sr^{90} in the Northern over the Southern Hemisphere during the spring of the Northern Hemisphere, and a minimum difference during the spring of the Southern Hemisphere. The seasonal trend of absolute values in the North Temperate Zone is especially marked.

The high geographic variability of fallout sampling and analyses requires "smoothing" by grouping of the data. Several methods can be used to smooth, or average, the data in order to compute the total global ground fallout. These methods can be compared to see if they are consistent as well as to determine the variability between the two methods.

The first method consists of determining the arithmetic average of Sr^{90} deposition for each 10 degree latitude band and drawing a smooth curve through these average latitudinal values. This method assumes that the arithmetic average of selected stations is representative of the average value for the whole latitude belt. Since there are only a limited number of stations, this average may bias the answer toward

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[1] From *Quarterly Summary Reports,* HASL-84, April 1, 1960; HASL-95, October 1, 1960; and HASL-111, April 1, 1961.

FIGURE 1.—SEASONAL LATITUDINAL CURVES OF STRONTIUM-90 DEPOSITION (JUNE 1958-FEBRUARY 1960)

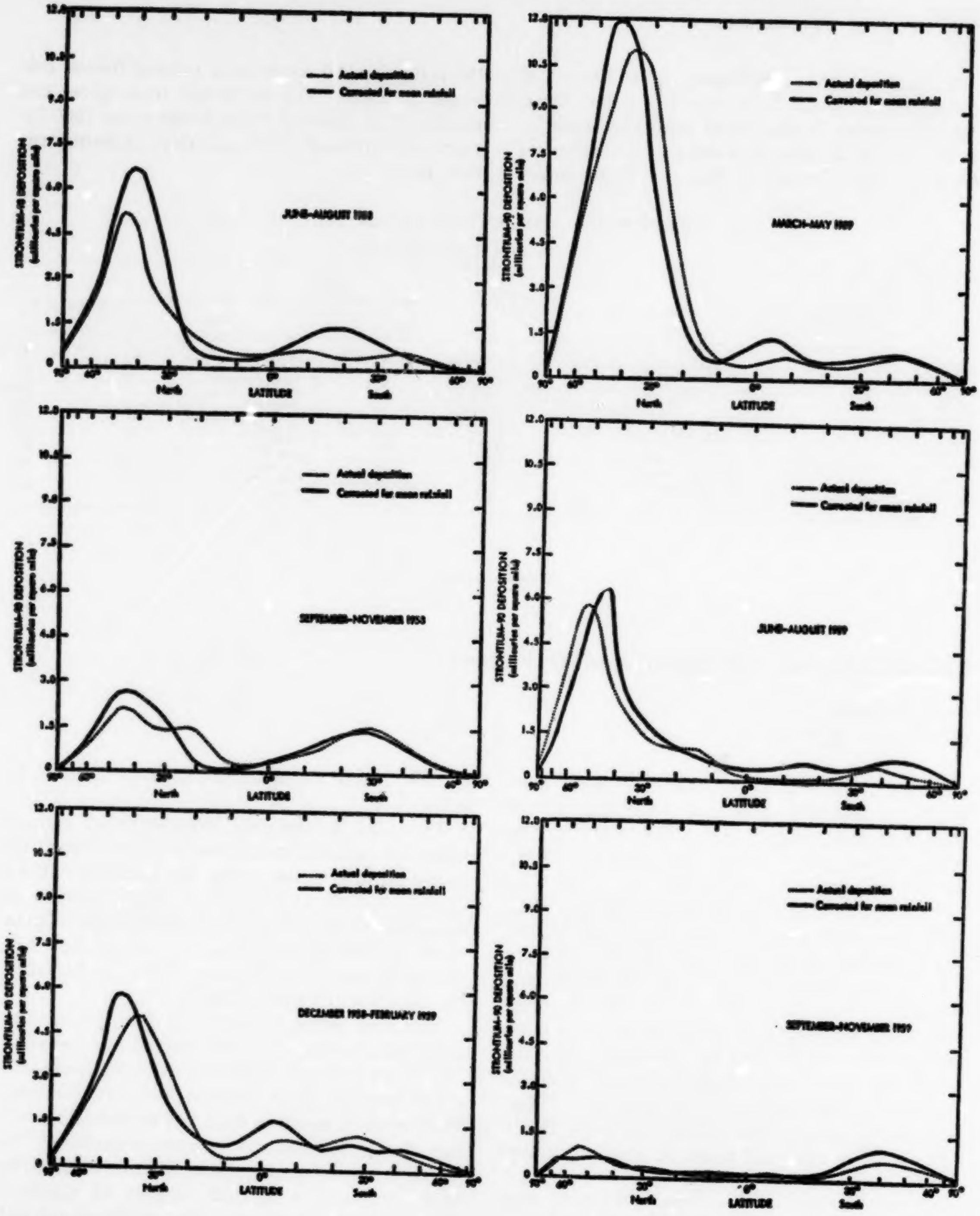

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FIGURE 1.—SEASONAL LATITUDINAL CURVES OF STRONTIUM-90 DEPOSITION Con.

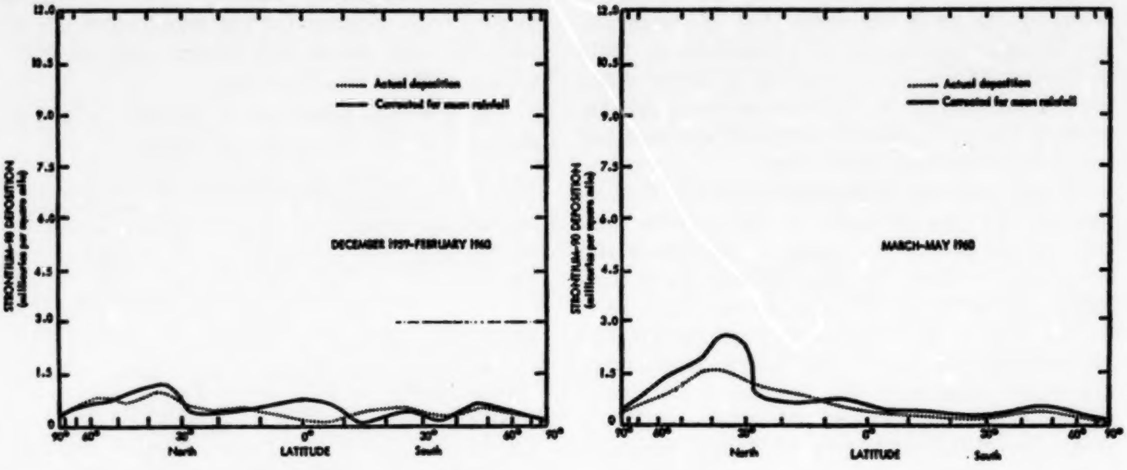

TABLE 1.—TOTAL WORLD GROUND DEPOSITION OF STRONTIUM-90, JUNE 1958–MAY 1960

[Deposition in megacuries]

Period	Method	Latitudes				Total	Average total	Difference[1] (percent)
		North			South			
		30°-90°	0°-90°	0°-90°	0°-90°			
June-Aug. 1958	Actual	0.13	0.05	0.18	0.04	0.22	0.26	27
	Rainfall correction	0.19	0.03	0.22	0.07	0.29		
Sep.-Nov. 1958	Actual	0.06	0.04	0.10	0.07	0.17	0.19	16
	Rainfall correction	0.09	0.02	0.11	0.09	0.20		
Dec. 1958–Feb. 1959	Actual	0.15	0.06	0.21	0.07	0.28	0.29	4
	Rainfall correction	0.16	0.06	0.22	0.07	0.29		
Mar.-May 1959	Actual	0.34	0.12	0.46	0.05	0.51	0.52	2
	Rainfall correction	0.37	0.08	0.45	0.07	0.52		
June-Aug. 1959	Actual	0.16	0.04	0.20	0.03	0.23	0.25	12
	Rainfall correction	0.16	0.04	0.20	0.06	0.26		
Sep.-Nov. 1959	Actual	0.06	0.03	0.09	0.03	0.12	0.12	0
	Rainfall correction	0.04	0.03	0.07	0.05	0.12		
Dec. 1959–Feb. 1960	Actual	0.037	0.026	0.063	0.041	0.104	0.110	10
	Rainfall correction	0.042	0.026	0.068	0.047	0.115		
Mar.-May 1960	Actual	0.056	0.042	0.098	0.029	0.127	0.143	22
	Rainfall correction	0.083	0.036	0.119	0.040	0.159		

[1] Difference (%) $= \left[\frac{2(\text{Method 1} - \text{Method 2})}{\text{Method 1} + \text{Method 2}}\right]100.$

higher values if most of the fallout stations are in rainy areas or toward a low answer if more are in a dry region.

The second method is an attempt to compensate for the climatic difference at sampling stations compared with the average rainfall in a latitude band. The specific activity (mc/mi^2/inch of rain) is determined for each station by months. The arithmetic average is then computed for the various latitude belts. To determine the total fallout, the average specific activity in each latitude band is multiplied by the precipitation in the same 10° latitude band. The precipitation in these bands are given by

Möller (3) for each of the four seasons. This method assumes that the average precipitation given by Möller is the same that has occurred for the time period under consideration. This treatment of the data may be in error since there is an inverse correlation between specific activity and precipitation amounts whereas the method assumes no correlation.

Smooth seasonal latitudinal curves of deposition for the two methods for the various time periods are shown in figure 1. Although the difference between the two methods for a particular 10° latitude belt can be as much as a factor of two, the significant features are approximately the same. The curves in this figure were integrated to give the total world ground fallout for the periods under consideration. The total world ground fallout for both methods, expressed in megacuries of Sr^{90}, are shown in table 1. Although there can be as much as a factor of two in the difference between the two methods for a given latitude belt, the difference between methods ranges from 2 to 27 percent for the world total. Probably the best world-wide fallout amount is an average of the two methods.

The average total world ground fallout in megacuries for these time periods is:

Period	Deposition	Total
June 1958–May 1959	1.26	1.26
June 1959–Nov. 1959	0.37	1.63
Dec. 1959–May 1960	0.25	1.88

REFERENCES

(1) Environmental Contamination from Weapons Tests, HASL-42, U.S. Atomic Energy Commission, October 1958 and subsequent *Quarterly Summary Reports*, HASL-51, 55, 65, 77, 84, 88, 105, 111 and 113.

(2) Strontium-90 on the Earth's Surface, TID-6567, February 1961, Office of Technical Information, U.S. Atomic Energy Commission.

(3) Möller, F., "Vierteljaharakarten des niederschlags fur die ganze erde", Peterm. Geogr. Mitt., 1, 1-7, 1951.

Registration Of Radiation Sources In California

Department of Public Health, State of California

The registration of radioactive materials, X-ray machines, and other radiation-producing equipment is mandatory under a law enacted by the State of California in 1959. This law, implemented by State Board of Public Health regulations adopted last year, provides for the collection of information relating to the number, location, and use of radiation sources in the State.

The first completed registration forms were

TABLE 1.—REGISTERED RADIATION INSTALLATIONS AS OF MARCH 15, 1961

Nature of installation	Number of installations [1]				Number of individual X-ray units reported
	Total	Percent of total	With radiation machines	With radioactive materials	
Private practices of:					
Dentists	5,737	43.8	5,737	----------	6,974
Physicians	3,558	27.1	3,490	206	4,220
Chiropractors	916	7.0	916	1	945
Osteopaths	586	4.5	583	16	615
Podiatrists	328	2.5	328	----------	331
Hospitals	485	3.7	474	129	2,089
Veterinarians or veterinarian hospitals	465	3.5	464	5	484
Miscellaneous medical services (including clinics, laboratories, health agencies, etc.)	389	3.0	371	33	579
Manufacturing industries	294	2.2	180	179	407
Miscellaneous service industries	109	0.8	66	71	279
Schools or colleges	86	0.7	67	51	202
Government installations, not shown elsewhere	87	0.7	52	41	141
Other	62	0.5	31	36	45
Total	13,102	100.0	12,759	768	17,401

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[1] The number of installations with radiation machines and the number with radioactive materials do not add to the total number of installations because 425 installations possess both radiation machines and radioactive materials.

filed in June 1960, shortly after the registration regulations became effective. By March 15, 1961, when 13,102 registrations had been filed and processed, it was possible to commence the task of tabulating the data for analysis and study. The response to the registration requirement has been very good. Many local health agencies have been participating actively in the registration program.

The first summaries of registration data, as of March 15, 1961, are now available. Tables 1 and 2 present information on the number and types of radiation installations registered. As used in these tables, an installation is defined as a location (professional office, building, plant, etc.) where one or more sources of radiation are used, operated, or stored. A separate registration is filed for each installation.

TABLE 2.—REGISTERED RADIATION INSTALLATIONS OF PHYSICIANS IN PRIVATE PRACTICE, BY SPECIALTY, AS OF MARCH 15, 1961[1]

Medical specialty	Number of installations [2]			Number o individual X-ray units reported
	Total	With radiation machines	With radioactive materials	
General medical practice	738	738	2	772
Internal medicine	425	414	16	432
Radiology, roentgenology and nuclear medicine	265	257	67	652
Dermatology	221	218	42	324
Orthopedics	193	193	----------	204
Urology	130	130	----------	139
Ear, nose, throat	43	28	21	28
Pediatrics	41	41	----------	41
Surgery	27	27	----------	28
Cardiology	25	25	1	26
Group practice (including various specialties)	156	156	9	217
Other specialty	88	76	16	89
No specialty stated	1,206	1,187	32	1,268
Total	3,558	3,490	206	4,220

[1] Not included are installations such as hospitals, clinics and health agencies n which radiation sources may be under the control of or used by physicians.

[2] The number of installations with radiation machines and the number with radioactive materials do not add to the total number of installations because 138 installations possess both radiation machines and radioactive materials.

Cesium–137—Potassium Levels In Eight Control Subjects[1]

C. E. Miller and J. B. Corcoran, Radiological Physics Division
Argonne National Laboratory, U.S. Atomic Energy Commission

The total-body gamma-ray spectra of 12 unexposed employees of the laboratory were measured with Human Spectrometer No. 1 on two dates during 1960. These subjects have been measured periodically, usually every three months, since March of 1955.

Their cesium-137 (Cs^{137}) body contents, expressed in units of μμc Cs^{137} per gram of natural body potassium, have been determined, and the levels in eight subjects are given for eight dates during the past 30 months in table 1. It will be noted that the average Cs^{137} content dropped from 55 μμc Cs^{137}/gmK during December of 1959, to 49.6 μμc Cs^{137}/gmK during May of 1960, and to 37.4 μμc Cs^{137}/gmK during December of 1960. This represents a 10 percent decrease in Cs^{137} content during the first five months of 1960 and 25 percent decrease during the last six months. The same percentage decreases were noted for the other four subjects for these last three dates, but their data were not included in the table since they had not been measured every time on the earlier dates.

A group of 11 male Chicago residents, age 40 to 70 years, measured during the last three months of 1960 contained an average of 38.8 μμc Cs^{137}/gmK. This value agrees with the amount found for the controls during December of 1960. The spread in individual values was somewhat greater in that they ranged from 20 μμc Cs^{137}/gmK to 60 μμc Cs^{137}/gmK while the values of the younger controls ranged from 27.9 to 55.9—a 2 to 1 spread.

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[1] Reported in *Semiannual Report*, ANL-6297, July-December 1960, Argonne National Laboratory, Radiological Physics Division.

TABLE 1.—CESIUM-137-POTASSIUM RATIOS IN EIGHT CONTROL SUBJECTS OVER A SPAN OF 30 MONTHS

[Average concentrations in μμc/gm K]

Subject	July 31, 1958	November 20, 1958	March 19, 1959	June 17, 1959	September 14, 1959	December 8, 1959	May 24, 1960	December 15, 1960
1	57	48.5	59	68.5	60	56.2	54	38.4
2	51.5	52	59	54.6	54.5	47.4	49	44.6
3	71.0	68.5	75.2	83.2	68.2	69.5	64.9	55.9
4	43	58	76	81	64.2	62	50.5	33.9
5	47	47.8	54.5	57.2	45.5	42.2	45.4	29.8
6	43.5	46.2	53.5	59	54.7	53.5	48.2	31.6
7	39	39.5	47	46	45.6	45.2	38.2	27.9
8	48.4	51	61.8	65.5	64	63.1	46.6	37.3
Average	50.0	51.4	60.7	64.4	57.1	55.0	49.6	37.4

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The United States Atomic Energy Commission is providing data on environmental levels of radioactivity in the vicinity of major Commission installations to the Public Health Service on a quarterly basis. The data are from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Radiological Health Data, Volume I, Numbers 8 and 9; and Volume II, Numbers 1 through 8 contain summaries for 17 installations. Summaries follow for the Knolls Atomic Power Laboratory and the S1C Prototype Reactor Facility for the third and fourth quarters of 1960.

Knolls Atomic Power Laboratory

General Electric Company, Schenectady, New York —Issued June 1961

Environmental levels of radioactivity at the Knolls Atomic Power Laboratory (KAPL) have been reported in *Radiological Health Data,* Volume I, Number 9, and Volume II, Number 1. The following report presents the data for the third and fourth quarters 1960, as well as the annual 1960 summary.

The principal responsibility of KAPL is to support the Naval Reactors Program for the Atomic Energy Commission in the development of nuclear power reactors for naval propulsion. The General Electric Company has been the operator of KAPL for the Atomic Energy Commission since 1946.

The Knolls Atomic Power Laboratory consists of two sites: the Knolls Site and the West Milton Site (see figure 1 for geographical locations). The former is located five miles east of Schenectady, New York, on the south bank of the Mohawk River. The West Milton Site is located approximately 18 miles north of Schenectady, in Saratoga County.

Small amounts of radioactive materials are released to the atmosphere and to two surface streams in the area—the Mohawk River at the Knolls Site and the Glowegee Creek at the West Milton Site. Prior to the release of this low level radioactivity to the environment, all KAPL liquid waste and exhaust air systems are carefully and continuously monitored. In addition to the in-plant control monitoring, an environmental monitoring program is conducted both on- and off-site. Environmental monitoring locations are also given in figure 1. A brief

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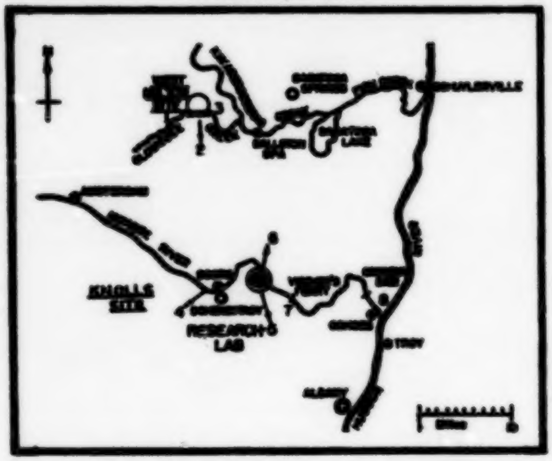
FIGURE 1.—ENVIRONMENTAL MONITORING LOCATIONS, KAPL



1. Glowegee Creek sampling station 150 feet upstream from the entrance of the West Milton Site effluent. Samples of Glowegee Creek water are collected weekly during the warmer seasons.
2. West Milton Site—Environmental radiation levels and particulate airborne radiation levels are sampled continuously at five geographically placed locations on the Site. Precipitation is sampled continuously.
3. Glowegee Creek sampling station 2,640 feet downstream from the West Milton Site. Samples of Glowegee Creek water are collected weekly.
4. General Electric Powerhouse, about eight miles upstream from the Knolls Site; Mohawk River water is sampled continuously.
5. General Electric Laboratory, 4,000 feet west of the Knolls Site, has a continuously operating radiation-level detector and air monitor for particulate airborne materials.
6. Knolls Site environmental particulate air and radiation levels are sampled continuously at three stations at different geographic locations. In addition, precipitation, continuous and proportional samples of combined sewer effluent are collected. Samples of soil and vegetation are collected periodically.
7. Mohawk River water is sampled continuously at the Vischer Ferry Powerhouse which is approximately two miles downstream from the Knolls Site.
8. Cohoes is approximately thirteen miles downstream from the Knolls Site. Samples of untreated Mohawk River water and the Cohoes drinking water are collected weekly.

description of the types of samples collected at the various locations is given in the referenced legend.

Environmental Airborne Radioactivity

Environmental airborne radioactivity is measured at three locations on the Knolls Site, four locations on the West Milton Site, and at the General Electric Company Research Laboratory approximately one mile west of the Knolls Site. Airborne radioactivity is sampled continuously and analyzed on a weekly basis. The average results of the airborne radioactivity analysis are given in table 1.

Measurements of airborne radioactivity are made at least 48 hours after collection to allow for the decay of naturally-occurring short half-life radionuclides.

TABLE 1.—GROSS BETA AIRBORNE RADIOACTIVITY

[Average concentrations in $\mu\mu c/m^3$]

Period 1960	Knolls site	West Milton site	Off-site
Third quarter	0.06	0.19	0.06
Fourth quarter	0.06	0.13	0.03
1960 summary	0.11	0.17	0.12

Liquid Radioactive Waste

Knolls Site

At the Knolls Site, all potential sources of liquid radioactive wastes are connected by control drains to collection tanks in the radioactive waste processing building. The release of liquid waste to the Mohawk River is regulated through the control and monitoring of the concentration of fission products in the collection tanks and the control of the discharge rate of the effluent. A daily continuous proportional sample of the Knolls Site combined sewer effluent is taken at the point of discharge to the Mohawk River. Analyses of weekly composite samples are made for radiochemical and toxic chemical content, and these analyses show that strontium-90 is the principal component which has to be considered in hazard control.

Mohawk River water is sampled at locations upstream and downstream from the Knolls Site. Sampling locations are at the General Electric Company Powerhouse eight miles upstream from the Knolls Site; at the point of discharge to the Mohawk River from the Knolls Site, at the Vischer Ferry powerhouse approximately two miles downstream; and at the City of Cohoes pumping station approximately 13 miles downstream. Tables 2 and 3 summarize the radionuclide content of the Knolls Site waste effluent, the amount dis-

TABLE 2.—RADIONUCLIDE CONTENT OF THE KNOLLS SITE WASTE EFFLUENT

Radionuclide	Third quarter	Fourth quarter	1960 summary
	Average concentration ($\mu\mu c$/liter)	Average concentration ($\mu\mu c$/liter)	Average concentration ($\mu\mu c$/liter)
Ce^{144} and Pr^{144}	1000	310	2300
Sr^{89}	590	230	1700
Sr^{90}	440	60	910
Cs^{137}	530	140	1800
Ru^{106}	----------	100	230
Zr^{95}	----------	150	390
I^{131}	----------	----------	76

TABLE 3.—GROSS BETA RADIOACTIVITY DISCHARGED AND DETECTED IN THE MOHAWK RIVER

[Average concentrations in μμc/liter]

1960 Period	Total waste discharged (millicuries)	Average concentration discharged	Upstream	Downstream			Precipitation at Knolls Site
			GE powerhouse	Vischer Ferry	Cohoes		
					Raw	Treated	
Third quarter	296	2,500	9	10	9	4	24
Fourth quarter	108	1,000	3	2	2	1	120
1960 summary	3,125	7,600	5	5	8	4	74

TABLE 4.—GROSS BETA DISCHARGED AND DETECTED IN GLOWEGEE CREEK

1960 Period	Total waste discharged (millicuries)	Average concentration discharged (μμc/liter)	Average concentration in creek		Precipitation (μμc/liter)
			Upstream (μμc/liter)	Downstream (μμc/liter)	
Third quarter	4.26	290	7	4	60
Fourth quarter	1.93	140	11	9	44
1960 summary	8.20	140	13	9	94

charged, and the gross beta concentrations detected in the Mohawk River water.

The Knolls Site effluent is monitored continuously for alpha radioactivity. Since the quarterly discharge rate is less than one percent of the most restrictive environmental limit for alpha (Pu^{239}), the data are not reported.

West Milton Site

The Glowegee Creek does not have a reliable dilution potential and therefore the radioactivity levels in the liquid waste from the West Milton Site are operationally controlled and diluted before release to the creek. Samples of the Glowegee Creek water are taken once a week at two locations, 150 feet above and 2,640 feet below the point where the West Milton Site effluent enters the creek. Table 4 presents the quantities of radioactivity discharged into and detected in Glowegee Creek samples. Since no alpha radioactivity is discharged from the West Milton Site, alpha analyses are not performed.

Precipitation has a variable effect upon the Glowegee Creek samples. This effect is dependent upon the amount of rainfall, creek flow and the period of sampling relative to the period of precipitation. The results of precipitation sampling are also found in table 4.

Soil samples are collected bi-weekly at two locations, one on the Knolls Site and the other off-site. The off-site location is approximately two miles northeast of the Knolls Site. The sampling location was selected after a four-year study of wind directions. This station was upwind of the Knolls Site exhaust stacks 98 percent of the time in the period tested. The results of the gross beta radioactivity analyses of the soil samples are in table 5.

TABLE 5.—GROSS BETA RADIOACTIVITY IN SOIL SAMPLES

[Average concentrations in μμc/gm]

1960 Period	Knolls Site	Off-site
Third quarter	20	20
Fourth quarter	22	22
Annual summary	19	21

General Conclusions

As a result of the environmental monitoring program conducted by the Knolls Atomic Power Laboratory at both the Knolls Site and the West Milton Sites, it is concluded that the operations at these installations did not adversely affect the radioactivity levels of the local environment. In addition, the results of the environmental survey indicate that the levels of radioactivity detected at all times were within the standards established by the U. S. Atomic Energy Commission based on the recommendations of the National Committee on Radiological Protection and Measurements.

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S1C Prototype Reactor Facility

Combustion Engineering, Inc.
Windsor, Connecticut

—Issued June 1961

Environmental levels of radioactivity at the S1C Prototype Reactor Facility have been reported in *Radiological Health Data*, Volume I, Number 9, and Volume II, Number 1. The following report presents a summary of the data for the third and fourth quarters of 1960.

The S1C Prototype is a land based nuclear submarine power plant facility. This facility is operated for the Atomic Energy Commission by the Naval Reactors Division of Combustion Engineering, Inc. at Windsor, Connecticut. The prototype contains a pressurized water reactor power plant which is used to conduct research and development work and to train personnel in operation of naval reactor power plants. Reactor power operations at the S1C prototype facility began in December 1959.

The low level radioactive waste discharged intermittently from S1C Prototype operations consists mainly of water. Small quantities of airborne particulate in gaseous waste are also generated and released on occasion in the ventilation exhaust air.

Essentially all of the radioactive waste originate from the activation of minute amounts of impurities in corrosion products in the circulating water used as a reactor coolant. Small quantities of gaseous waste result from the activation of minute amounts of air dissolved in the coolant water.

Airborne Waste Effluent

Ventilation air from the submarine hull and the supporting facility at the prototype site may, at times, contain small amounts of airborne radioactive particulate or gaseous activities. This ventilation air is discharged to the environment at below permissible levels through an exhaust stack. The ventilation air is continuously monitored for radioactivity by particulate and gaseous counters which control the discharge of ventilation air. Alarms are sounded if the concentration approaches permissible limits. When these limits are exceeded, the exhaust air is discharged through a high efficiency filter bank or the ventilation system is completely shut down and the hull sealed. Table 1 presents the results of the airborne waste effluent monitoring at the exhaust stacks. Table 2 shows gross beta-gamma concentrations in air samples taken on-site downwind at the point of release.

FIGURE 1.—ENVIRONMENTAL MONITORING LOCATIONS, S1C PROTOTYPE SITE

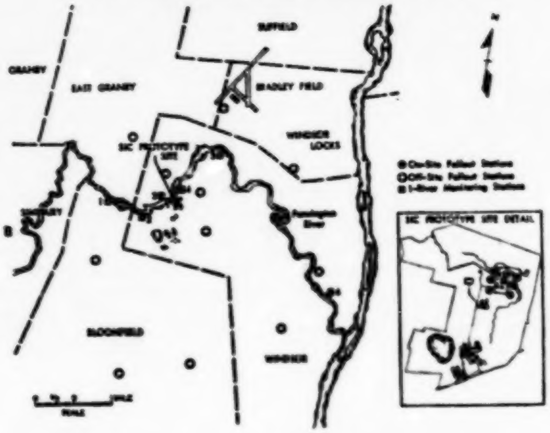

TABLE 1.—GROSS BETA-GAMMA CONCENTRATIONS IN EXHAUST STACK EFFLUENTS

[Average concentrations in μμc/m³]

1960 Period	Gross beta-gamma
Third quarter	46
Fourth quarter	68
Annual summary	56

TABLE 2.—GROSS BETA-GAMMA CONCENTRATIONS ON SITE DOWNWIND OF RELEASE POINT

[Average concentrations in μμc/m³]

1960 Period	Gross beta-gamma
First quarter [1]	7.4
Second quarter [1]	25
Third quarter	22
Fourth quarter	25
Annual summary	20
Pre-operational (fourth quarter 1959)	62

[1] Not previously reported.

Radioactive fallout is collected on a weekly basis at six locations around the site and analyzed for gross radioactivity. Off-site fallout collections in neighboring towns are also made and analyzed for gross radioactivity. A comparison is then made between the on-site and off-site stations. Locations of the various fallout stations are shown in figure 1. The on-site and off-site fallout data are presented in table 3.

TABLE 3.—GROSS BETA CONCENTRATIONS IN FALLOUT

[Average Concentrations in mc/mi^2/month]

1960 period	On-site		Off-site	
	Number of samples	Gross beta	Number of samples	Gross beta
Third quarter	71	1.28	117	1.11
Fourth quarter	48	0.39	74	0.31
Annual summary	231	1.85	325	1.63

Preoperational averages from October to December 1959 showed an average of 2.00 mc/mi^2/month for prototype site fallout stations and 2.04 mc/mi^2/month for the fallout stations located in neighboring towns. From table 3, it can be seen that the fallout on-site is essentially the same and is at a very low level. This fallout has therefore been attributed to residual activity from weapons tests rather than from S1C Prototype operations.

Farmington River Monitoring

Liquid wastes are collected in 5,000 gallon retention tanks. When a tank is full, it is sampled and analyzed for its radioactivity content. If the activity is below the allowable discharge limit, the tank contents are released into the industrial waste system. If the limit is exceeded the contents are diluted below acceptable limits in a 25,000 gallon dilution tank and then released. Table 4 is a summary of the gross radioactivity released to the Farmington River.

TABLE 4.—SUMMARY OF GROSS BETA-GAMMA RADIOACTIVITY RELEASED TO THE FARMINGTON RIVER

1960 period	Total for period (millicuries)	Average concentration released ($\mu\mu c$/liter)
Third quarter	2.94	1,800
Fourth quarter	4.70	2,600
Annual summary	7.78	800

The Farmington River is sampled monthly at various locations as shown in figure 1 for determination of alpha and beta-gamma activity in river water and mud. The results of this sampling are presented in tables 5 and 6.

TABLE 5.—GROSS RADIOACTIVITY OF WATER SAMPLES FROM THE FARMINGTON RIVER

Location number (see figure 1)	Third quarter 1960				Fourth quarter 1960				Annual summary 1960	
	Number of samples	Alpha ($\mu\mu c$/liter)	Beta-gamma ($\mu\mu c$/liter)	Uranium (ppm)	Number of samples	Alpha ($\mu\mu c$/liter)	Beta-gamma ($\mu\mu c$/liter)	Uranium (ppm)	Number of samples	Beta-gamma ($\mu\mu c$/liter)
Upstream										
1	[a] 4	68	7.1	0.003	3	206	16.5	0.001	20	30.0
2	4	172	13.9	0.002	2	294	1.0	0.003		
Outlet										
3	4	315	16.5	0.006	2	339	2.5	ND	9	6.1
Down-stream										
4	4	114	4.9	0.002	1	149	9.0	------------	30	8.9
5	4	84	4.6	[b] ND	3	276	49.5	0.003		
6	4	188	4.9	ND	3	105	15.0	ND		

[a] Includes results for June, not reported previously.
[b] ND—Non-detectable.

TABLE 6.—GROSS RADIOACTIVITY OF MUD SAMPLES FROM THE FARMINGTON RIVER

Location number (see figure 1)	Third quarter 1960				Fourth quarter 1960				Annual summary	
	Number of samples [1]	Alpha (μμc/gm)	Beta-gamma (μμc/gm)	Uranium (ppm)	Number of samples	Alpha (μμc/gm)	Beta-gamma (μμc/gm)	Uranium (ppm)	Number of samples	Beta-gamma (μμc/gm)
Upstream										
1	2	31.7	0.92	2.39	3	1.8	3.66	0.58	16	2.5
2	2	0.9	0.13	0.40	2	4.5	4.70	3.23		
Outlet										
3	2	3.2	0.86	2.33	2	2.1	5.49	5.29	7	3.0
Down-stream										
4	2	1.0	0.95	0.57	2	11.8	4.36	1.14	15	2.8
5	0	---	---	---	0	---	---	---		
6	2	0.6	3.11	0.55	3	1.9	2.14	0.56		

[1] Includes results for June, not reported previously.

General Conclusions

The data for the year show that there is no significant contribution of radioactivity to the environment from the S1C Prototype Reactor Facility. Furthermore, the radioactivity discharged to the environment under controlled conditions from the S1C Prototype were in compliance with the recommendations of the National Committee on Radiation Protection and the radiation protection standards established by the Federal Radiation Council.

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